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The S. S. "Imperator" of the Hamburg-American Line

The first keel-plate of the S. S. "Imperator" of the Hamburg-American Line, was laid on the stocks of the Vulcan Yard, Hamburg, on June 18, 1910. About two years later, or May 23, 1912, the vessel was launched and ready for her steam trials in April, 1913. She is the first German ship to have four propellers, and is twice the size of the next largest ships of this line, viz., the "Amerika," and the "Kaiserin Auguste Victoria." As being the largest ship in the world, the "Imperator" has enjoyed wide popularity with the press. It is the intention of this article to describe briefly the dimensions, the arrangement for safety and the most important engineering features of this latest achievement of the merchant marine.

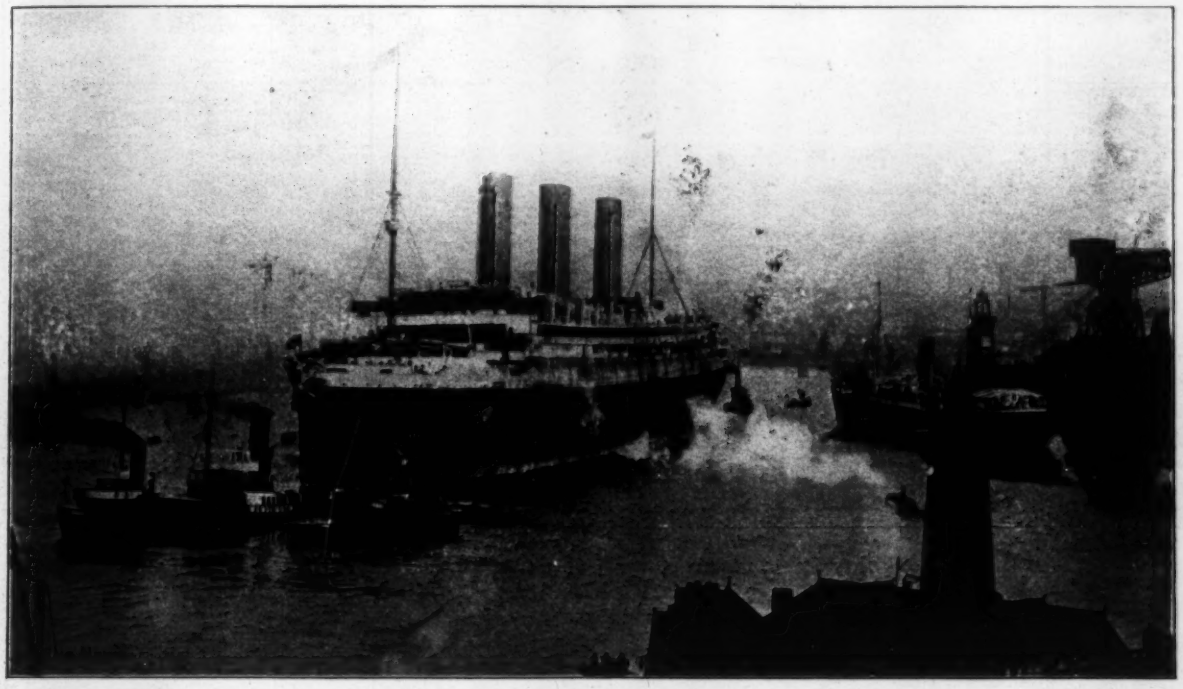

FIG. 1. THE HAMBURG-AMERICAN LINE STEAMER "IMPERATOR," IN HAMBURG HARBOR

DIMENSIONS

The length of the vessel over all is 918 ft. 10 in.; the beam, 98 ft., and the height, 100 ft. 4 in. from keel to boat deck, and 246 ft. from keel to masthead. The gross registered tonnage is 52,117 tons, and the displacement (when laden) is 57,000 tons; the draught under this condition is 35 ft. 6 in.

The passenger capacity is 4020, while the crew numbers 1180. It is worth noting that all of the 720 first-class passengers can be served simultaneously in the main dining room, situated on the sixth deck. There are nine decks in all. The ballroom is 72x58 ft., by 18 ft. in height. This room is rendered especially enjoyable from the fact that there are no columns; the roof being supported by three bowstring lattice girders.

PROVISIONS FOR SAFETY

The water-tight compartment system is the most comprehensive to be found on any ship afloat. The bulkheads are fitted with 36 Dorr water-tight doors, automatically controlled from the bridge, and closed by hydraulic and electric power. The hull is divided into thirteen water-tight compartments by twelve water-tight transverse bulkheads; eight of which extend up to the second deck far above the level water line. The hull, for a third of its length forward, is further provided with a longitudinal water-tight bulkhead on each side at a distance of 59 in. from the outer hull plates. In order to test their safety, four of the compartments were flooded simultaneously, and the steel partitions proved to be water-tight in fact, as well as in name.

The great number of passengers and crew made the

problem of providing sufficient life-boat capacity, one requiring careful attention. The "Imperator" is equipped with 83 boats, including two motor boats, accommodating 5500 persons, or 300 in excess of the maximum demand. Instead of crowding all the boats on the sun deck, in the usual manner, a large number have been placed on the lower promenade deck. This is a new departure and has led to the adoption of a new method of launching. The boats are launched by the Welin system, whereby one man controls the launching of a boat.

In addition to the foregoing precautionary measures, there is that of vigilance and responsibility. The vessel carries four captains commanded by a commodore. There is, therefore, always an officer with the rank and authority of a captain, in command. The fourth captain directs the movements of the crew.

The Machinery

The driving power aggregates 62,000 hp. ahead, and 35,000 hp. astern. The ahead turbines are four in number; a high- and an intermediate-pressure unit on the two inner shafts, and two low-pressure turbines, each weighing about 380 tons and developing about 16,000 hp., on the two outer shafts. The astern turbines consist of two high- and two low-pressure units, on the inner and outer shafts respectively. Each separate shaft is available for running. The propellers are 16 ft. 5 in. in diameter, and revolve at 185 r.p.m. at a ship speed of 22.5 nots. The total turbine installation has 760,000 bronze blades. The drums of the low-pressure turbines are 11 ft. 10 in. in diameter and 17 ft. in length, and carry 50,000 blades.

The condensing system comprises four condensers of pear-shaped cross-section, each with a cooling surface of over 16,150 sq.ft. They are cooled by four centrifugal pumps 4 ft. 3 in. in diameter. The air pumps are four in number and of the dual type of Weir. They are 40 in. diameter. Four double feed pumps draw the feed water from the tank in the double bottom and, with the assistance of four main feed pumps, deliver it into the boilers.

There are 46 single-ended, water-tube boilers of the modified Yarrow type arranged in four rooms. Steam is generated at a pressure of 235 lb. The total heating surface of the boiler installation is 203,000 sq.ft. and the total grate surface is 3760 sq.ft. The Howden forced-draught system is used. Four steam-bilge pumps, each with a capacity of 4944 cu.ft. per hr., empty the bilges of the engine and boiler rooms continuously.

The electrical installation consists of five 2000-amp., 110-volt turbo-generators. They carry a maximum motor load of 850 hp., and a lighting load represented by 10,000 lamps. In addition to these dynamos, there is a gasoline engine-driven emergency dynamo installed on the boat deck. Should the main service fail, this machine will illuminate the boat deck and, at the same time, supply current for operating the apparatus on the bridge, and that of the wireless telegraph station. The latter apparatus has a maximum range of 1500 nautical miles.

The "Imperator" left Cuxhaven, at the mouth of the Elbe, on June 11, and Southampton on June 12, for her maiden regular trip, arriving at New York on June 17 after a most satisfactory voyage.

Fig. 2. The Drum of One of the Turbines of the "Imperator"

Fig. 3. Lowering One of the Turbines into Position in the "Imperator"

Fig. 1 is a view of the "Imperator" as she appeared in the harbor of Hamburg, before starting on her first transatlantic voyage. Fig. 2 is one of the turbine drums. The apparent enormous size of the latter vanishes when compared with the huge hull of the vessel, as shown in Fig. 3.

Action of Alkali and Sea Water on Concrete; the U. S. Bureau of Standards Report

The United States Bureau of Standards has just issued a bulletin* giving the results of a 3½ years' investigation into the effect of alkali and sea water on concrete, a subject upon which any amount of matter has been written but which has never been very thoroughly studied in an experimental way. The work of the Bureau con-

*"Action of the Salts in Alkali Water and Sea Water on Cements," by P. H. Bates, Chemist, A. J. Phillips, Assistant Chemist, and R. J. Wig, Associate Engineer Physicist, Bureau of Standards. [Nov. 1, 1912.] Technologic Papers of the Bureau of Standards, No. 12.

sisted of numerous laboratory tests upon mixtures of various salts with cement mortars and the examination of the effect of actual sea water (at Atlantic City, N. J., where a laboratory was established) upon concretes of different composition.

The report is quite lengthy (157 large-size pages) and contains numerous tables, diagrams and views. The results of the investigations to date, as expressed by the authors of the bulletins, are as follows:

SUMMARY

The conclusions must be limited by the scope of this investigation and since the physical tests reported cover a period of exposure not exceeding 3½ years the conclusions should be considered as somewhat tentative.

1. Portland-cement mortar or concrete, if porous, can be disintegrated by the mechanical forces exerted by the crystallization of almost any salt in its pores, if a sufficient amount of it is permitted to accumulate and a rapid formation of crystals is brought about by drying; and as larger crystals are formed by slow crystallization, there would be obtained the same results on a larger scale, but in greater time if slow drying were had. Porous stone, brick and other structural materials are disintegrated in the same manner. Therefore in alkali regions where a concentration of salts is possible, a dense nonporous surface is essential.

2. While in the laboratory a hydraulic cement is readily decomposed if intimately exposed to the chemical action of various sulphate and chloride solutions, field inspection indicates that in service these reactions are much retarded if not entirely suspended in most cases, due probably to the carbonization of the lime of the cement near the surface or the formation of an impervious skin or protective coating by saline deposits.

3. Properly made portland-cement concrete, when totally immersed, is apparently not subject to decomposition by the chemical action of sea water.

4. While these tests indicated that portland-cement concrete exposed between tides resisted chemical decomposition as satisfactorily as the totally immersed concrete, it is felt that actual service conditions were not reproduced, and therefore further investigation is desirable.

5. It is not yet possible to state whether the resistance of cements to chemical disintegration by sea water is due to the superficial formation of an impervious skin or coating, which is subsequently assisted by the deposition of shells and moss forming a protective coating, or by the chemical reaction of the sea salts with the cement forming a more stable compound without disintegration of the concrete, or by a combination of both of these phenomena.

6. Marine construction, in so far as the concrete placed below the surface of the water is concerned, would appear to be a problem of method rather than materials, as the concrete sets and permanently hardens as satisfactorily in sea water as in fresh water or in the atmosphere, if it can be placed in the forms without undue exposure to the sea water while being deposited.

7. Natural, slag, and other special cements tested in concrete mixtures showed normal increase in strength with age both in sea water and in fresh water.

8. In the form of neat briquettes most of the portland cements of high iron content, several of the cements of high or normal alumina content and one special slag cement did not show any marked difference in tensile strength whether exposed to fresh or sea water for all periods up to two years. Other cements of various compositions showed signs of disintegration after a few weeks.

9. All cements resisted disintegration in sea water better in mortar mixtures than in the form of neat briquettes. In most cases the mortar briquettes had normal strength up to two years' exposure.

10. The physical qualities of the cement, which depend essentially upon the method of manufacture, would seem to determine its resistance to decomposition when brought into intimate contact with the sulphate and chloride solutions.

11. Contrary to the opinion of many, there is no apparent relation between the chemical composition of a cement and the rapidity with which it reacts with sea water when brought into intimate contact.

12. Tricalcium-sulpho-aluminate could not be formed, and therefore disintegration could not result from this cause.

13. In the presence of sea water or similar sulphate-chloride solutions:

(a) The most soluble element of the cement is the lime. If the lime of the cement is carbonated it is practically insoluble.

(b) The quantity of alumina, iron or silica present in the cement does not affect its solubility.

(c) The magnesia present in the cement is practically inert.

(d) The quantity of SO_3 present in the cement up to 1.75% does not affect its solubility, but a variation in the quantity present may affect its stability by affecting its rate of hardening.

14. The change which takes place in sea water when brought into intimate contact with the cement is as follows:

(a) The magnesia is precipitated from the sea water in direct proportion to the solubility of the lime of the cement.

(b) The sulphates are the most active constituents of the sea water and are taken up by the cement. Their action is accelerated in the presence of chlorides. No definite sulphate compound was established.

(c) The quantity of chlorine and sodium taken up by the cement is so small that no statement can be made as to the existence of any definite chloride or sodium compound formed with the cement.

15. The SO_3 added to a cement in the plaster to regulate the time of set is chemically fixed so that it will not go into solution when the cement is brought into intimate contact with distilled water.

16. Metal reinforcement is not subject to corrosion if embedded to a depth of 2 in. or more from the surface of well-made concrete.

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Trouble with Micro-organisms in the Mechanical Filters of Louisville, Ky*

By Frederick H. Stover†

Low turbidity and bacteria in the Ohio River water at Louisville, Ky., are liable to be accompanied by a shortening of the runs between cleaning and by "grassy" to "fishy" odors in the water, due largely to microörganisms. The latter are chiefly diatoms, with a few algae and miscellaneous forms, the whole sometimes accompanied by considerable amounts of fine flocculent amorphous matter. The river water at such times usually has a turbidity of less than 30 parts per million and frequently as low as 5 to 10 parts, while the bacterial counts will vary from 300 to 3000 at the lower turbidities.

At Louisville the water is pumped from the Ohio River to two open reservoirs with a total capacity of 100,000 gal., which permits of four days (theoretical) sedimentation. The filter runs sometimes drop, with low turbidities, from 40 to 25 hours between washings. In May, 1913, with few organisms, but much amorphous matter, the decrease was from 30 to 9 hours between washings. A definite relation between frequent washings and organisms, amorphous matter and unusually fine turbidity has not been established, but each of the three seems to be a factor.

The effect of these factors on the filters is to give an increased loss of head, accompanied by a compacting of the sand and sometimes a sticking together of the sand grains. This, of course, increases the requisite amount of wash water. Thus, during 1912 the average amount of wash water was 2.05% of the volume filtered, the lowest average for any one month being 1.44%. During the period of shortened filter runs the amounts varied from 6 to 10.7%.

The methods of treatment [tried to meet the troubles outlined] have been killing by chemicals, increased coagulation and bypassing the basins, or drawing water directly from the river.

No means for accurately proportioning a solution of hypochlorite to the volume of water under treatment being available, the water over each filter was drawn down to within 3 in. of the surface and 12 lb. of powder scattered uniformly over a 30x72-ft. bed. The bed then stood 24 hours, after which it was washed and put into service. No improvement in length of run followed, and the bacterial efficiency of the bed was much below the normal for several days after the treatment.

With copper sulphate applications, remarkably favorable results have been secured in all but one instance, and even in this case the results cannot be said to have been negative. The copper was applied in the second sedimentation basin and in the coagulant basin, by dragging bags of it from a boat. It is probable that equally good results could be se-

*Abstract of a paper read before the American Water Works Association, Minneapolis, June, 1913.

†Chemist, Louisville Filtration Plant, Louisville, Ky.

cured by applying it as a solution. In plants not provided with sedimentation basins, but which run the incoming water direct to coagulant basins, at least 12 hours should be allowed for the application of the copper and the filtering of the water, and a slightly longer period would be desirable if possible.

The copper sulphate used has been (four occasions) 1.3, 1.3, 1.7 and 1.2 parts per million, at costs of 6.5, 10.4, 21.7 and 13.2c. per million gallons treated [variations due to variations in amount of water dosed; "treated" may mean filtered—Ed.]. At $30 per million gallons as the value of wash water, about $150 was saved at one time and $228 at another. The doses were effective for from 19 to 9 days. Careful examinations showed no traces of copper. Of numerous fish of many varieties, none were injured.

Bacteria increased after the copper treatment, probably because it removed or reduced unfavorable conditions. No B. coli were detected, and it was found that 0.25 part per million of available chlorine would eliminate the increase.

Doubling the normal dose of coagulant increased the removal of organisms by only 10%, and had very little effect in increasing the length of run.

By-passing the river water direct to the coagulant basins gave encouraging results in two instances, but increases in turbidity cut short the experiments.

The Sedgwick-Rafter filter (a miniature sand filter) was used advantageously to determine the rapidity with which water from the river and from the settling basins could be filtered. This will in some instances enable the operator to select the water from that point of his system which will give the longest filter runs.

A Swiss Hydro-Electric Station Using Water under 2800-Ft. Head

In the design and construction of the power station at Arniberg, Switzerland, near Amsteg on the St. Gothard Ry. and some ten miles above the upper end of Lake Lucerne, all the problems of high head, long pipe lines and new turbine design were encountered. The results, as disclosed by an article in London *Engineer*, Feb. 28, 1913, are interesting.

The immediate district is thinly populated and non-industrial, so that the station gets the most of its load by feeding the stations at Altdorf, seven miles away, and Rathhausen, near Lucerne, thirty miles away. To the one is supplied three-phase current at 48 cycles, and to the other three-phase current at 42 cycles.

Water is obtained from two glacier-fed streams and from springs, and is collected in an artificial lake from which it is led through two parallel pipes 6850 ft. long, varying from 2 ft. to 18 in. in diameter. At the power-house end, the two pipe lines are connected by a cast-steel double bend anchored in a concrete block. When repairs are found necessary to either part, it may be shut o without closing down the whole plant. Each has waste pipe which discharges into the tailrace, and is con trolled by a sluice valve at the main pipe line with a reg ulating valve at the tailrace end to relieve the sluice valv when being closed. The station is arranged for thre 3000-hp. units and one 1300-hp., although at presen only the 1300-hp. and one of the 3000-hp. units are i place. The latter is concreted to the main pipe line b a 12-in. wrought-iron branch pipe and there is an 8-in. pipe for the smaller unit. The T-connection for each branch pipe carries a valve for shutting off unit; this is a nozzle type, with balancing pistons to relieve the pressure of 1200 lb. per sq.in., hand controlled by spur gears and chain drive from the generator room; for tight closing under the high head it is fitted with leather rings protected by bronze liners.

The waterwheels are a Pelton type, the smaller-capacity unit having the larger diameter in order to operate at lower speed. As shown in Fig. 1, the small-power turbine has a generator at each end, while the other machine is coupled to a single generator. On account of the fairly uniform load on the station and the successful development of an accurate regulating mechanism, flywheels have been dispensed with in the equipment of the units. In the case of the 3000-hp. wheel, a forged-steel disk, carrying the buckets at its periphery, is bolted to the flanged end of the generator shaft. The buckets, of special steel, highly polished, are held between the disk and a circular steel plate riveted to it. By this method of fixing the buckets, individual replacement is impossible but it is reported that the water is pure so that uniform wear on the buckets can be expected. The housings of the wheel and governor are bolted to the generator bedplate. These casings are so disposed that the water, after discharge from the bucket, is guided along a gradual curve into the tailrace. A short shaft is coupled to the outer face of the wheel disk and carried through a bearing on the housing to drive the governor gears.

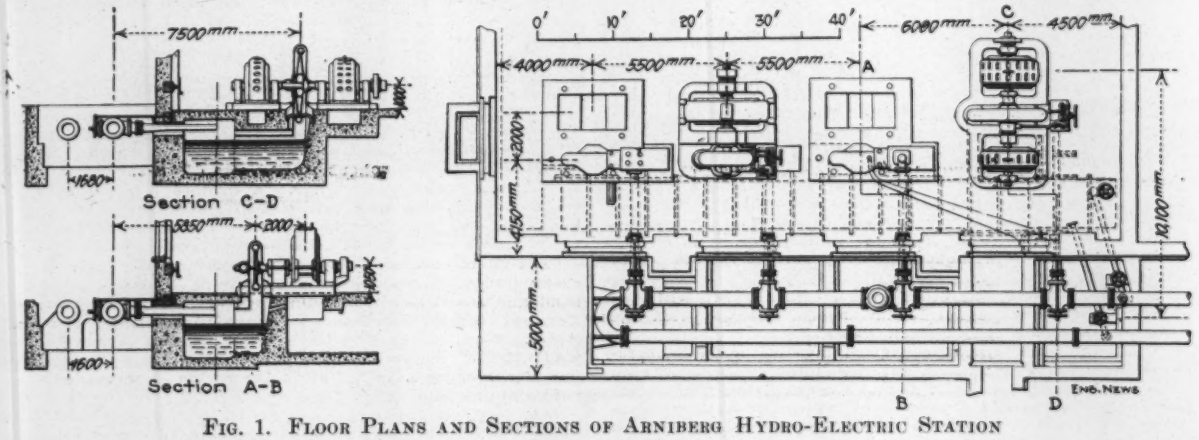

FIG. 1. FLOOR PLANS AND SECTIONS OF ARNIBERG HYDRO-ELECTRIC STATION

Water is led to the wheel through a cast-steel bend and nozzle secured to the foundation. The area of the nozzle is adjusted by a needle in the usual way under control of the governor. On account of the head of 2800 ft. and a pipe-line length of 1¼ miles, a quick, sensitive governor was needed. The contract conditions provided that throwing off the whole load should not cause the speed

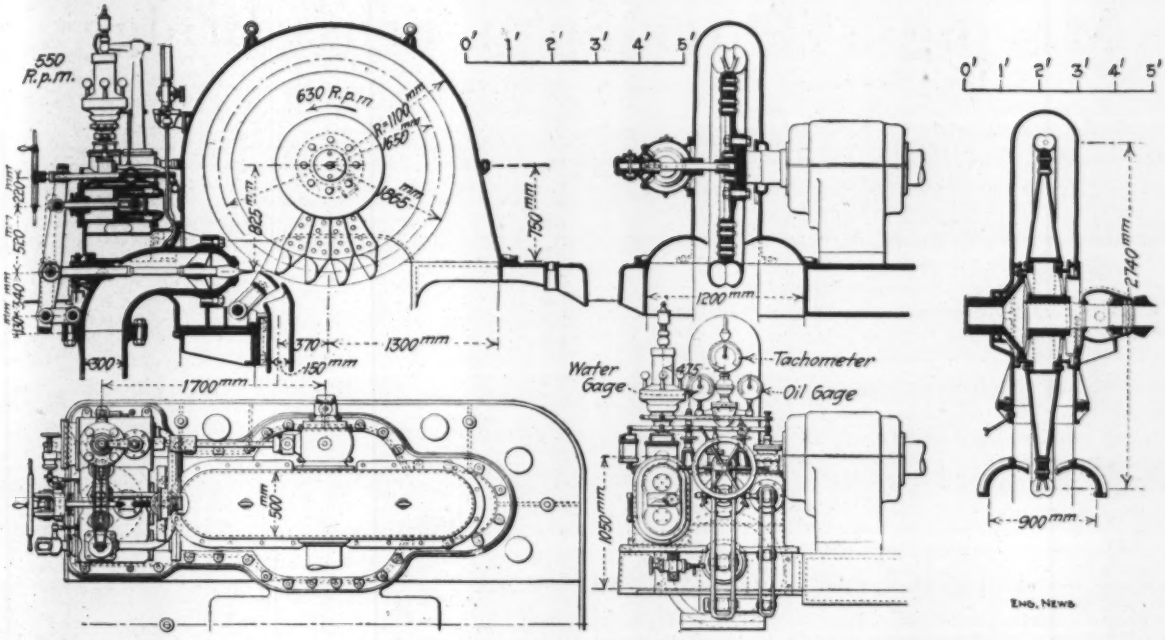

FIG. 2. PLAN, ELEVATION AND SECTIONS OF 3000-HP., 630-R.P.M., 2800-FT. HEAD PELTON WHEEL; AND SECTION OF 1300-HP., 360-R.P.M. WHEEL

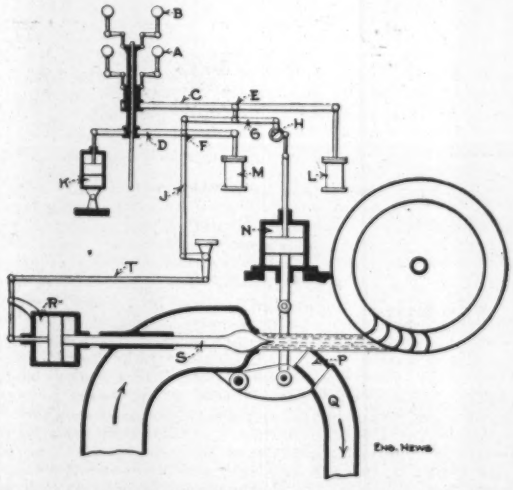

FIG. 3. DIAGRAM OF NEEDLE-DEFLECTOR GOVERNOR FOR ARNIBERG WHEELS

to increase to more than 8% above normal. Two difficulties had to be overcome, for any sudden closing of the nozzle would create an excess pressure, which would tend to increase the speed, and any such sudden closing would induce water-hammer in the pipes. It was not found advisable to shift the jet bodily for changes in load, since it was believed that the mechanism would soon become leaky and inpingement of the jet at a wrong angle on the bucket would induce rapid wear.

The governor is called a "double spring pendulum type" and has two flyball systems, *A* and *B*, acting on two levers, *C* and *D*, with fulcrums at *E* and *F* respectively. The fulcrum *E* is carried by the bar *G* which has one end connected to the eccentric *H* and the other to the vertical rod *J*. The lever *D* is connected to a dashpot *K*, which prevents its moving except slowly. The levers *C* and *D* control the regulating valves *L* and *M*, respectively. The valve *L* operates the piston ("servo-motor") *R*, controlling the needle valve *F*. The valve *L* operates the piston *N*, to control the position of the deflector *P*. When the turbine changes its speed slowly, the levers *C* and *D* are moved by the governors in unison; the needle valve *S* and the deflector *V* are moved simultaneously, the proportion of design being such that the deflector is always brought finally into a position tangential to the jet but not quite in contact with it. If, however, the speed of the turbine increases quickly the levers *C* and *D* move in different ratios on account of the dashpot *K*. As a result, the deflector cuts into the jet and spills a portion of it down the waste pipe into the tailrace. The needle valve *S* is meanwhile slowly closing the orifice. When the size of the jet, proper to the reduced load, has been established by the needle, the deflector *P*, through the agency of the rods *T* and *J* and the lever *G*, with the eccentric *H*, is again brought tangential to the stream but just out of contact with the new diameter of jet. As the deflector follows all the slow movements of the needle valve and is always about to touch the jet at its every size, there is no idle movement to effect when it is necessary to cut into the jet on a sudden change of load. Trials have indicated that, by suddenly throwing on 97% of full load, there was first a drop of 11.03% followed by a return to normal and a rise of 4.8% above. This was in turn followed by lesser oscillations which were soon damped out. When the 97% full load was suddenly taken off, the increase of pressure was 5% and lesser oscillations in pressure followed but were soon damped out.

These turbines were designed and built by Theodore Bell & Co., of Kriens, Switzerland.

Moving a Three-Span Truss Bridge*

By C. E. Smith†

SYNOPSIS—The shifting of the Missouri Pacific Ry. bridge over the Kaw River at Kansas City was a noteworthy piece of work necessitated by the disastrous flood of 1903. To adjust the bridge to the new channel its three truss spans of 180 ft. were first raised about 9 ft. above their original elevation. Then the three spans, as one 540-ft. structure, were swung laterally to the new alignment by a radial motion giving a shift of about 3 ft. at one end 26 ft. at the other end. Finally, the three spans (connected to form one structure) were moved about 123 ft. longitudinally to seat them on the new piers. All this involved very delicate work and very careful planning, especially as the bridge had to be kept open for traffic. The foundation work for the new substructure was complicated by the presence of a tangled mass of wreckage of bridges, cars, etc., buried in the river bed. The commencement of the work was delayed by various causes, and the bridge alterations were only completed in 1912. The accompanying article, by the engineer who was in charge of the work, describes in detail the series of operations in building the new piers and placing the old spans upon them.

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At the time of the great flood in the Kaw (or Kansas) River at Kansas City, in 1903, the main line of the Missouri Pacific Ry. crossed the river on a double-track bridge consisting of three 180-ft. steel truss spans on masonry piers and abutments. The original footings were 10 ft. below the bed of the river, resting on piles driven to a depth of about 20 ft. About 100 ft. above it was a similar bridge of the Union Pacific Ry. When the water rose this was weighted with cars and locomotives to try and hold it, but the pressure of the water and drift was so great that the superstructure was carried away and (with the cars and drift) lodged under the Missouri Pacific Ry. bridge, forming almost a solid dam, so that the water passed over the tops of the locomotives which had been run on the latter bridge to hold it in position. This bridge stood the pressure, however, and was the only one of the 17 bridges that did not go out.

The War Department appointed a board of engineers to consider plans for improving the situation, and the Kansas legislature created the Kaw Valley Drainage District, with power to issue bonds to cover the cost of the improvements. The plans originally provided for a 600-ft. channel with concrete retaining walls, bridges to be raised and to have not more than two piers in the channel, and all piers to be carried to solid rock. The cost of the walls, however, led to the adoption of levees, with a 734-ft. channel. As nearly all the bridges had been built in 1903 and 1904, many of their owners (including all the railways) offered to reconstruct their bridges on new piers and abutments (adding such spans as might be necessary), and as that involved maintaining more than two piers in the river, the companies offered to join in the expense of widening the river so as to compensate for the additional pier. This being objected to by the Drainage Board, the matter was taken into court. The companies objected also to founding the piers on rock, as being unnecessary, since the river did not scour more than 15 ft. below low water, and pile foundations below that level would be amply sufficient. This contention was upheld by the courts.

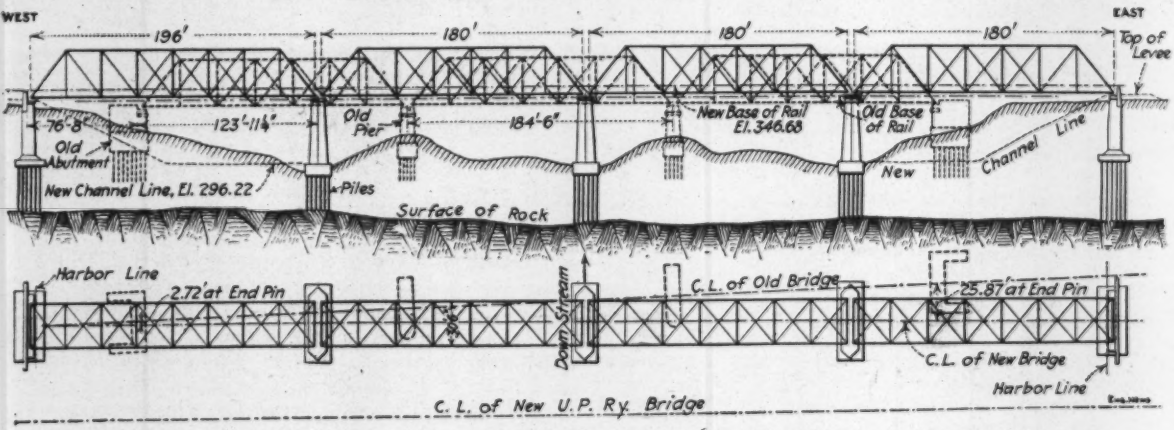

Fig. 1. Plan and Elevation of the Kaw River Bridge of the Missouri Pacific Ry. at Kansas City, Kan.

(Showing the old and new substructures and the old and new positions of the superstructure.)

As to the bridge piers, the court permitted the Union Pacific and Missouri Pacific railways to use their existing truss spans, putting them on new substructure and each adding one span, the width between harbor lines being increased from 734 ft. to 742 ft. at the bridges, to compensate for the width of the third pier. This work involved shifting the old spans so that one end would be at the new harbor line, adding one 196-ft. span, and raising the entire structure about 9 ft., the cost for each company being about $500,000. As two overhead bridges crossed the approaches to the river bridges, the reconstruction of the latter could not proceed until arrangements had been made for altering the former, and this condition resulted in a delay of several years. In the spring of 1910, in anticipation resulted in a delay of several years. In the spring of 1910, in anticipation of a flood, both the river bridges were raised 2½ ft., which was as high as they could be placed without interfering with the overhead bridges. Another year was lost in negotiations but finally work was started on the Union Pacific bridge in March, 1911, and on the Missouri Pacific bridge in September, 1911.

GENERAL CONDITIONS

The reconstruction of the Missouri Pacific Ry. bridge and the location of the new piers were designed with a view to making use of the three former steel truss spans 180 ft. long, which had been built in 1900 and designed for Cooper's E-50 loading. The additional width of the revised river necessitated the addition of a 196-ft. span. Although 734 ft. had been decided on as the width between tops of levees, a modified width of 742 ft. between the extreme front faces of the abutments was chosen to compensate for the width of the third pier. Fig. 1 shows the bridge as built originally and as now reconstructed.

*Abstract of a paper on "Reconstructing and Moving the Kaw River Bridge of the Missouri Pacific Ry. at Kansas City, Kan.," read before the Associated Engineering Societies of St. Louis, on May 7. The paper deals very fully with the great flood of 1903 and the conditions which led to the reconstruction of the bridge, but this portion we have summarized in the first two paragraphs of our abstract. The levee work along the river was described in our issue of Dec. 26, 1912. Editor.

†Bridge Engineer, Missouri Pacific Ry., St. Louis, Mo.

The modified harbor lines were so located with reference to the old bridge as to necessitate an extension of 123 ft. at the east end and 73 ft. at the west end. Since the original construction of the bridge, the entire yard area at each end had been built up with tracks, resulting in a disagreeable reverse curve at the east end which would have been made worse by extending the bridge on its old alignment. The west end of the bridge was fixed by a number of conditions that prevented any large side movement. The alignment finally chosen necessitated moving the west end of the bridge 9.4 ft. upstream and the east end 26.3 ft. upstream.

After careful study involving the consideration of a number of different schemes, it was decided to treat the three spans as one structure and to move them at one time. This conclusion was reached on account of the necessity of keeping the bridge in almost continuous service during the reconstruction. The construction of a temporary bridge was considered, but was discarded as uneconomical and difficult to maintain.

During 1904, the Union Pacific Ry. had removed part of its old bridge and other débris from under the Missouri Pacific bridge, but had neglected to remove the débris below the water surface. Soundings and borings directly under and in the immediate vicinity of the latter bridge indicated that the débris had not moved since 1903, but that on account of having fallen into the river when the bottom had scoured to unusual depth, much of it was buried 15 to 20 ft. deep in the river bed. It extended up to low water, forming a twisted and tangled mass of heavy steel members, extending the entire width of the river. Inquiry developed that this condition was well known to contractors and that it would be impossible to let the foundation work on other than a force-account basis. Consequently the contract was awarded on a force-account and fixed-fee basis to the Union Bridge & Construction Co., of Kansas City, Mo.

Another condition that influenced the award of the work on a force account basis was the heavy railway traffic and the congested areas in the vicinity of the bridge. The Missouri Pacific Ry. runs the largest number of passenger trains into and out of Kansas City, about 60 in each direction daily. About 25% of these trains cross the bridge on their regular runs, and all the trains cross the bridge between the Union Depot and the coach yard, where the cars and engines are cleaned and trains made up. This makes about 150 passenger train movements each day. Switching movements and through drag freights up to 80 cars in length were also numerous, making about 400 movements across the bridge daily.

On acount of the location being at the throats of two yards, all movements were slow, resulting in practically a continuous stream of traffic on each track. The Union Pacific bridge was under reconstruction only 75 ft. away on the south side, and stock-yards and packing houses were close against the tracks and the river bank on the north. The presence of two stock undercrossings and three overhead bridges under reconstruction at the bridge ends, added to the other congestion, made this a very busy place.

CLEARING THE RIVER CHANNEL

Before work commenced on the piers, many methods of getting through the obstructions in the river bed were considered, and the use of pneumatic caissons and of steel sheet-piling were discussed. It was realized at once that the latter could not be depended on to cut its way through such a tangled mass of steel, and the railway company did not entertain with pleasure the thought of the cost of cutting through the steel débris under the edges of caissons, especially in view of the fact that bridge pins and joints, car axles and wheels, and other very heavy steel parts would be encountered.

As it had been agreed that it would be necessary to remove this material in some manner over the entire river bed, the decision reached was to clear the bottom of the river by dredging through the water with orange-peel and clam-shell buckets before placing any coffer-dams. The first barge was put to work at pier No. 2. Several carloads of car trucks, rails, steel members, truss joints, floor beams, bridge stringers, cars and other débris were dredged from the site of each pier. When it was realized how slow this work would be, a second barge was started and night and day shifts were worked.

The dredging was a tedious operation. The bucket would land on steel time after time and come up empty. It would take hold of a mass of iron and fail to move it, or it would get caught in the obstructions and require care to free it. As a rule, however, the free material was dredged as deep as possible around and among the old bridge work. When the dredge failed to bring up any more material, a diver was sent down to attach dynamite to the steel and thus break it up until the parts were sufficiently loosened to be removed. Much of this dredging and dynamiting was done in 30 ft. of water. This method of dredging was continued until all débris was removed from an area somewhat larger than the coffer-dams.

A very stiff blue clay was encountered about 55 ft. below the rail level, and there were few obstructions in this, except such as projected into it from above.

ABUTMENTS

Work started on the east abutment Sept. 1, and on the west abutment Oct. 14, 1911, and was carried on when work could not be prosecuted on the piers. These abutments (Fig. 1) are buried piers 26x54 ft. at the bottom of footing, 50 ft. 6 in. below the rail, and each is supported on 96 piles. The footings are 7 ft. deep. There are no wings, but to prevent the fill behind the back-walls from running onto the bridge seats, the back-walls are extended 9 ft. beyond each end of the pier, forming cantilevers of reinforced concrete connecting the back-walls to the levee.

To carry traffic over the excavations for the abutments the track ties and ballast were first removed from under one track at a time (between trains), and replaced by bridge ties and timber stringers. The stringers were composed of three 8x16-in. timbers under each rail. These were 28 ft. long, packed into a chord 70 ft. long with joints staggered to form 14-ft. panels. Excavation was then continued (under traffic) under these stringers, which were carried on temporary blocking, gradually increasing in height until sufficient depth had been reached to permit the installation of 60-ft. deck plate-girder spans. A wide flooring of blocking was placed for the support of the girders and a quick change made between trains. Open excavation was then carried down with sloping sides to about 14 ft. below the bottoms of the girders and the ground leveled off.

Below this level different methods were followed for the two abutments. At the east abutment, a coffer-dam 26 ft. 10 in. by 54 ft. 10 in. was framed at the bottom of the open excavation, and the interior space excavated by hand. No settlement of the surrounding earth occurred.

The west abutment was in close proximity to the Kansas City Southern Ry. bridge and the stockyards bridge. As the cylinders of the latter bridge were only a few inches from the edges of the excavations for the abutment, and as this bridge had to be kept in service, it was decided to employ other means than at the east abutment for sheeting the excavation. Consequently, bracing frames of 12x12-in. timbers were made and 3-in. sheeting driven by mauls outside of them, belt braces being inserted every 4 ft. as the excavation progressed. When a depth of 16 ft. had been reached, a second course of sheeting planks was driven inside the upper braces and additional braces were placed.

No settlement was experienced until a depth of about 40 ft. had been reached, at which point the sheeting was driving very hard and it was necessary to keep the excavation lower than the bottom of the sheeting. A layer of clean coarse sand was then struck, and while excavating so that the sheeting could be driven, the sand ran into the excavation like sugar, causing the cylinder piers under the stockyards bridge to settle 8 in. in one day. The weight was removed from the cylinders by bridging across the tracks and supporting the bridge on frame bents and blocking. The excavation was then continued and the abutment brought to completion in a manner similar to the east abutment, without further trouble. The rock was 10 ft. higher under the west abutment than under the east abutment, so that piles penetrating 30 ft. reached rock. This abutment was practically completed Feb. 17, 1912.

PIERS AND FOUNDATIONS

The footings of the old piers were 15x45 ft., and each pier was supported on 75 piles, having an average penetration of 20 ft. No settlement had ever taken place. The footings of the new piers were designed 18x54 ft., with 108 piles under each. The footings were established with the bottom about 60 ft. below the rail, and made 8 ft. thick, the pile heads projecting 5 ft. into the footing. The shafts of the piers are 12 ft. 6 in. wide at the top of footing and 9 ft. wide under the bridge seat coping course. The upstream ends are pointed to avoid the collection of drift and the downstream ends are pointed for symmetry. The upstream ends and shoulders of the shafts are reinforced by steel rails for the purpose of offering greater resistance to wear from ice and drift.

While the dredging of the channel was in progress, the coffer-dams for the piers were being built on shore. These were 20x56 ft. The sides were built solid with 12x12-in. timbers laid horizontally, well drifted together, and sheeted on the outside with 2-in. tongued-and-grooved lumber. The

sides were stiffened at intervals by verticals 12x14 in., held by 12x12-in. braces in both directions in horizontal planes about 4 ft. apart. This inside bracing divided the coffer-dam into rectangular pockets 10x11 ft.

In order to avoid damage to the lower edge in case the coffer-dam should land on an obstruction lower than the dredge had reached, steel cutting edges were provided. After about 8 ft. of a coffer-dam had been built it was launched, towed into correct position and sunk by building up the sides. When the cutting edge rested on the bottom and the coffer-dam was in correct position, the material inside was removed by dredging through the water. As the previous dredging had extended so deep, the settling of the coffer-dam to correct elevation was a comparatively simple operation, taking from one to two weeks at each pier. No obstructions of any kind were encountered during the sinking.

On account of the porous nature of the sub-soil below the blue clay, it was not possible to pump out these coffer-dams,

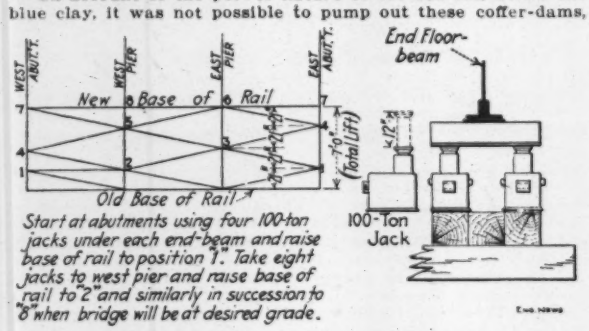
WEST ABUT'T.
WEST PIER
EAST PIER
EAST ABUT'T.
New Base of Rail
Old Base of Rail
End Floor-beam
12"
10" (Total Lift)
100-Ton Jack
Start at abutments using four 100-ton jacks under each end-beam and raise base of rail to position "1." Take eight jacks to west pier and raise base of rail to "2" and similarly in succession to "8" when bridge will be at desired grade.

FIG. 2. DIAGRAM SHOWING THE SERIES OF LIFTS IN RAISING THE THREE-SPAN BRIDGE TO ITS NEW ELEVATION

so the piles were driven through the water. As the sub-soil consisted of a clean sand, it was necessary to use powerful 2-in. jets for jetting the piles down to rock. Under each pier 108 piles were driven to a penetration of 24 to 30 ft.

The driving of these piles under the bridge, which had not yet been raised, was a tedious operation, especially in those portions of the footings that came under the old spans. At those places it was necessary to handle the piles from the deck of the bridge by derrick car, in order to stand them up within the coffer-dam and they were started down by short blows of a drop hammer working close to the bridge. When they had been driven sufficiently to permit room for steam hammer, that was placed on them and the jets were set to work. When the tops of the piles reached the water level, they were driven further by the aid of a follower, until they reached rock. The pile driving consumed from two to three weeks at each pier.

After the piles were all driven in a coffer-dam, a hydraulic dredge or sand-sucker was used to remove the accumulated sand and débris down to the proper level, after which a 5-ft. sealing course of concrete was placed around the pile heads by means of a tremie. The tremie consisted of a 10-in. steel pipe surmounted by a square trough, dished in the shape of a steel wheelbarrow tray. The bottom of the tremie was placed on the bottom of the excavation and the pipe filled with 1:2:3 concrete, mixed very wet. The tremie was moved slowly from side to side of the coffer-dam, working from end to end between the rows of piles until the desired thickness of 5 ft. was placed. The sealing course was then allowed to set six days. The coffer-dams were then pumped out in a very short time, although the head of water was 25 to 30 ft. After the pumping a 1-in. steam jet kept the water out. The piles were cut off 6 in. above the sealing course and the remainder of the concreting was finished in the dry.

The term "in the dry" came near being a joke as applied to the middle pier. The concrete in that pier had been placed to 14 ft. above the footing and was 5 ft. below the water level when it was learned that a flood wave was coming down the river which would raise the water 15 ft. and overtop the coffer-dam. As the other two piers were safely out of the water all efforts were concentrated on the middle pier, and the building of forms and depositing of concrete went on simultaneously and continuously, night and day. The concrete and the flood reached the top of the coffer-dam about the same time, but the level of the concrete was maintained about one foot above the level of the flood until the crest was reached. The concrete was raised 20 ft. in 24 hr., and some fear was felt as to the possibility of the forms bursting, especially as large cakes of ice coming down the river were striking the forms violent blows. After the flood subsided, however, it was found no damage had been done and the concrete set as well as any in the bridge.

In the construction of the tops of the piers it was necessary to make provision for the track and stringers which were being placed to carry the bridge when moving it longitudinally, which movement required the trucks that were to carry the spans to pass over the new piers considerably below their tops. The ends of the piers were finished to final height to provide supports for the spans, and recesses 8 ft. 3 in. deep and 24 ft. 6 in. long were left in each pier (see Fig. 10).

On account of the late start, and the time consumed in clearing the river bed, all the concrete was placed during the winter, which was unusually severe. Most of the concrete was placed when the temperature was between zero and freezing. The usual precautions of heating the materials and keeping the concrete warm by fires and tarpaulin covers were taken, with satisfactory results. Work was stopped several times when the temperature was below zero, as it was considered best not to take any unnecessary chances. The three piers were practically completed March 16, 1912.

PLANS FOR MOVING THE SUPERSTRUCTURE

During the construction of the foundations, the contract for shifting the superstructure had been let to the Jobson-Gifford Co., of New York, and the specifications provided that work would commence Jan. 1, 1912. On that date the contractor with his superintendent arrived at the bridge and after spending two days looking over the site they were much discouraged, as the continuous streams of traffic on both tracks and congestion in all directions indicated the difficulty of the work. Unfortunately, this contractor had bid on the job without visiting the bridge, but after the railway company insisted that it was too late to re-advertise for bids with any hope of getting a new contractor on the work in time to get clear of the spring floods, the contractor arranged to go ahead, and from that time on pushed the work with great energy. Pile driving and preparations for raising the spans started the middle of January.

It was decided to proceed in the following manner: 1, raise the spans to full height; 2, move the spans over on to the new alignment; 3, shift the spans endways; 4, erect the new span.

RAISING THE SUPERSTRUCTURE

As the bridge had been raised 2½ ft. in 1910, the remaining raise amounted to about 6½ ft. It was decided that

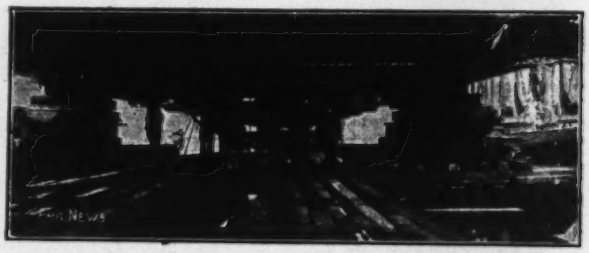

FIG. 3. BRIDGE SUPPORTED ON BLOCKING AT ITS NEW ELEVATION AND READY TO BE MOVED

(Under the I-beam grillage at each side is a sand-jack, shown in Fig. 11.)

one end of a span 180 ft. long could be raised one-fourth the total lift higher than the other end without detriment to traffic, resulting in a grade of about 1% on the span. The Kansas City Southern Ry. and stockyards bridges were still in the way while the jacking was going on, but by making a very sharp incline in a distance of about 50 ft. it was found possible to raise the west end of the bridge one lift of about 1½ ft. The diagram, Fig. 2, shows the numbers of the various lifts that were made. The contractor furnished only sufficient jacks to lift on one pier at a time. These were 100-ton jacks of 12-in. stroke, arranged as shown in Fig. 2.

The connections of the end floor beams to the trusses were strengthened by placing flat plates with pin holes bored in them over the ends of the truss pins, the plates extending vertically upward and being bolted to the outstanding legs of the stiffener angles, which happened to be properly spaced for this purpose.

The work of lifting was slow but the work of removing the overhead bridges was slower, and the jacking was very nearly delayed by their presence. They were removed a few days ahead of the day on which it would have been neces-

sary to either quit work or make another raise at the west end of the bridge. As the bridge was raised the load was carried on 12x12-in. blocking, which had to be arranged on each pier with three purposes in view: 1, carrying the truss shoes in their former location; 2, carrying the jacks for raising; 3, making preparations for carrying the load in the new locations that would be assumed by the truss shoes after the side movement.

The intermediate spaces were filled with blocking for the purpose of carrying the trusses while the bridge was being rolled sideways. Rough timber was used for the blocking. Surfaced timber would have been better but that was not thought of until too late.

As the bridge had to be kept in service continuously it was impossible to jack for long periods, but arrangements were made to give the bridge over to the contractor for about 40 min. in the forenoon and about an equal time in the afternoon. During each of these periods the greatest possible lift was made, usually about one foot, although the amount of lift varied with a number of conditions. For example: one Monday morning after an all-day Sunday rain the timber under the jack seats was so soaked and swollen by the rain that it consumed very nearly the entire jacking period to squeeze the water out, and no progress was made on account of the bridge having to be returned to service before the trusses were raised. Jacking was started March 1, and the spans were all up to full height on March 14.

As originally constructed, the trusses rested on pedestal

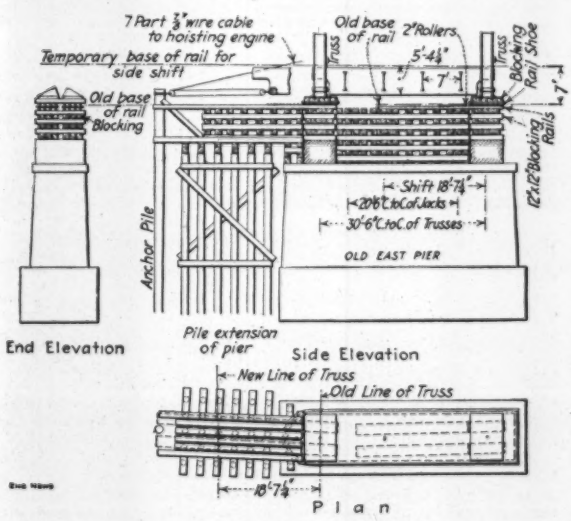

FIG. 4. BLOCKING ON OLD EAST PIER, WITH SIDE EXTENSION OF PIER TO CARRY THE BRIDGE WHEN SHIFTED LATERALLY

stones 2 ft. high, which in turn rested on the bridge seats. When the spans had been raised 2½ ft. in 1910 the pedestals had been built up by grillages of I-beams buried in concrete, which made their tops 4½ ft. above the top of the main pier. The further raise of 6½ ft. made the pile of timber blocking on the piers 10 to 11 ft. high for the support of the jacks and for the support of the spans in their new positions. Fig. 3 shows the bridge supported on blocking at its new elevation.

RAISING THE APPROACH TRACKS

Track raising in the yards at the ends of the bridge was started Oct. 1, 1911, and was well advanced by the time the bridge raising commenced. The tracks were raised as close as possible to the bridge, and dropped down to the bridge level by short sharp grades with a view of minimizing the amount of track raising while the bridge was being raised. This track work required the raising of about 12 miles of main and yard tracks which could not be taken out of service for long periods. At one throat it was possible to get the track for only 30 min. each day. This condition required the use of material that could be easily worked and about 200,000 cu.yd. of sand and cinders were used.

The sand was obtained from borrow pits on the river front that had been filled by the hydraulic method, and the borrow pits were later filled again by the same method. Although much of this work was done in severe winter weather the sand could always be easily handled and good track conditions were maintained throughout.

MOVING THE SPANS LATERALLY

Pile driving for the falsework to support the superstructure while moving it to its new position was started Jan. 26, 1912. For the reason that much of the falsework came under the trusses in their old location and could only be driven from the bridge, it finally became necessary to take one track over the bridge out of service continuously.

For the side movement at the west abutment, amounting to 2.7 ft., a frame bent was set on the upstream projection of the footing course, and the blocking on the pier was extended over it to form a support for the trusses in their new position. At the two river piers and the east abutment, posts were set on the footing projections and pile bents were driven 3 ft. apart, each bent having five piles 3 ft. apart. The blocking on the piers and east abutment was extended out over these bents to form pile pier extensions for the support of the upstream trusses after their movement, as shown in Fig. 4.

Just before rolling sideways, the trusses were jacked up and the blocking immediately under the shoes was removed and replaced by two nests of rails separated by rollers, Fig. 5. The lower nest consisted of four rails spaced 7 in. apart, and covering the new and old locations of the truss shoes as well as the space between them.

The upper nests consisted of four inverted rails slightly longer than the width of the shoes. Between the upper and lower rails were placed a number of 2-in. rollers 4 ft. long, made into nests by angle irons which served as spacers for the rollers. The length of each nest was equal to the width of shoe plus half the distance through which the shoes were to move. The rollers were spaced 6 in. apart for the rolling. As it was necessary to put them in under some shoes several days in advance of the movement, the rollers were spaced 3 in. apart in order to avoid danger of the rails cutting into them and increasing the difficulty of rolling.

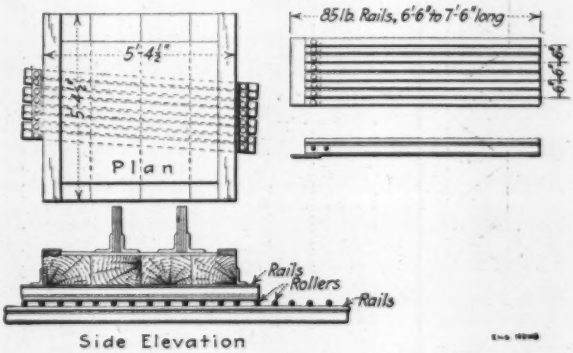

FIG. 5. RAILS AND ROLLER SHOES FOR MOVING TRUSSES

When all the shoes had been placed on rollers, the ice in the river was broken up by a sudden rise and the river rose rapidly, reaching a point considerably above the tops of the old piers and so far up on the blocking that serious consideration was given to the temporary removal of the rollers. The rising water and the ease with which the spans could have been rolled off the piers appeared to invite a catastrophe. Arrangements were made to load the bridge with coal cars heavily loaded with sand in case of necessity, but the rise was not great enough to require that precaution.

The side movement of the bridge amounted to 3.4 ft. at the west abutment, 11 ft. at the west pier, 18.6 ft. at the east pier and 26.3 ft. at the east abutment. A large cypress pile was driven as an anchorage at the end of each pier and each abutment, and falls (consisting of 7-part ⅞-in. steel cable) were placed between the pile anchor and the truss shoes at each support, the lead lines extending to hoisting engines. The lead lines were operated by derrick cars at each end of the bridge and by hoisting engines on flat cars over each pier.

As the side movement of the bridge was not the same at each support it was necessary to make a motion somewhat similar to the spoke of a wheel, the center of rotation being 60 ft. west of the west abutment. This is shown by the diagram, Fig. 6. In order to permit this to be done with ease, the direction in which each truss shoe had to move was carefully calculated and the rails and rollers placed so that

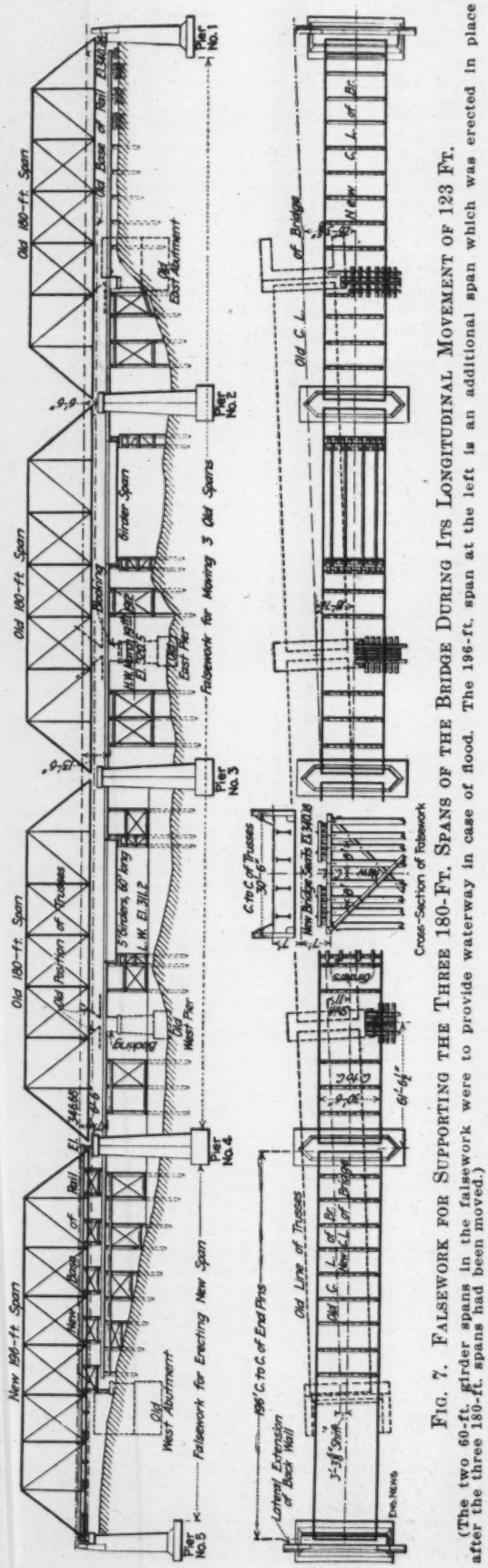

FIG. 7. FALSEWORK FOR SUPPORTING THE THREE 180-FT. SPANS OF THE BRIDGE DURING ITS LONGITUDINAL MOVEMENT OF 123 FT.

(The two 60-ft. girder spans in the falsework were to provide waterway in case of flood. The 196-ft. span at the left is an additional span which was erected in place after the three 180-ft. spans had been moved.)

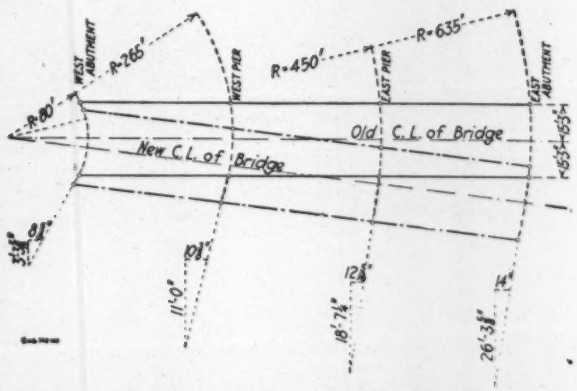

FIG. 6. DIAGRAM SHOWING RADIAL MOVEMENT OF THE BRIDGE IN SWINGING IT TO ITS NEW ALIGNMENT

the motion would take place along a chord to the curve through which the shoe moved. The angle of inclination of the rails and rollers was different at each support, on account of the different distances from the center of rotation.

It was thought that considerable difficulty would be experienced in so controlling the side movement that the west end of the bridge would move 3.4 ft. while the east end was being moved 26.3 ft., the intermediate portions to be moved their proper amounts. The movement was so well controlled by the men at the hoisting engines, however, that at no time was the bridge more than 2 or 3 in. out of line. The men understood what was expected of them and the side movement went off smoothly.

The track was cut at 10:35 a.m. and connected up again in the new location at 1:15 p.m., April 5. The entire time the track was out of service, including the track changes and blocking at the ends of the bridge, was 2 hr. 40 min., of which 50 min. was consumed in the movement of the spans. The actual rolling consumed only about two minutes.

PREPARATIONS FOR MOVING THE SPANS LONGITUDINALLY

The superstructure having been raised to its new elevation and shifted laterally to its alignment, the next step was to move it longitudinally in order to seat the spans on the new piers.

The winter of 1912 was unusually severe and the Kaw River ice broke up early, coming down the river on a rise in great heavy floes. Had it broken up a few weeks later no trouble would have been experienced, but the heavy rains caused a sudden rise which also brought down considerable drift. The Union Pacific Ry. had a temporary tramway trestle entirely across the river just upstream from the Missouri Pacific bridge, and little effort was made to keep the ice and drift moving through the trestle. The result was that the drift jammed against it and formed a mat, the pressure against which washed out six or seven bents with a rush.

They came down with such impact as to carry out seven bents of the Missouri Pacific falsework, causing the railway a loss that compensated for its saving in cost of pumping at the east abutment. For several weeks the current was too swift and the water too deep to allow of replacing the piling. When it became possible to redrive, it was decided to install a 65-ft. deck plate girder opening at the point of washout, in order that there might be less difficulty in passing drift in case of another flood.

During the raising and side movement of the bridge the driving of falsework piles was prosecuted continuously, and when the side movement was made, practically all the piles had been driven. The falsework consisted of blocking on the ground at each end of the bridge landward of the old abutments and pile bents in the river. The bents were spaced 14 ft. apart. Each bent was composed of eight piles, driven to refusal with drop hammer without the jet, the piles of each bent being capped with a 12x12-in. timber. This false work is shown in Fig. 7.

The U. S. Government required that provision be made to take care of navigation by providing a 60-ft. deck plate-girder span in the middle channel of the old bridge. Four pile piers of 16 piles each were driven for the support of the four 64-ft. girders that the railway decided to put in. When these piles were cut off the water was up to within a few

inches of the cutoff and rising, and the caps were set in place in the water. After the girders were in place the water rose over them and remained up for some time. It never fell below the caps until after the longitudinal movement. This rendered it impossible to put any transverse or longitudinal bracing on the pile piers. Fig. 8 shows one of the girders being taken from a barge and placed on the bents by a derrick car standing on the bridge.

A large proportion of the other falsework piling was also driven during comparatively high water and many bents were not braced. The condition of the falsework in this respect was far from what was desired during the longitudinal movement, but on account of the near proximity of the spring flood period it was decided not to wait to place the bracing.

The girders and falsework stringers and ties were placed on the bents to form supports for two standard-gage tracks 15 ft. 6 in. c. to c., 11 ft. below the tracks on the bridge. The falsework stringers consisted of four chords, each consisting of three-ply 8x16-in. by 28-ft. stringers breaking joints to form 14-ft. panels. Standard bridge ties 7x8 in., 9 ft. long, were laid, with 75-lb. rails forming a continuous double-track 660 ft. long, from the new east abutment to the old west abutment, passing through the openings that had been left in the new piers.

MOVING THE SPANS LONGITUDINALLY

For the longitudinal movement of the bridge many methods had been considered, among them the use of small rollers

FIG. 8. DERRICK CAR ON THE BRIDGE TAKING A FALSEWORK GIRDER FROM A BARGE AND SETTING IT ON THE PILE BENTS

(The water has risen nearly to the caps of the bents.)

and the use of car-trucks. The small rollers were not used as it was found that the number of rollers and other necessary apparatus would have been very expensive. The car trucks were not used because no satisfactory method could be worked out to certainly avoid the overloading of individual trucks, the failure of any one of which would have been disastrous. The decision was reached to use special trucks built of timber and standard car wheels, axles and journal boxes, so constructed and distributed under the bridge as to spread the load as much as possible.

As the falsework piles had been driven during high swift water, many of them fetching up on obstructions at slight penetration, and as the falsework was deficient in bracing, the truck supports were so worked out that the bridge would ride over a soft spot in the falsework without trouble, by transferring a part of the load from one truck to the other. As the load on any axle under the best conditions would be high, it was decided to use only axles and wheels that had been tested in actual service. Consequently, 72 axles and pairs of wheels were removed from 50-ton coal cars, and were made up into 24 trucks. The construction is shown in Fig. 9.

Each truck consisted of three pairs of axles (six wheels) spaced by 12x12-in. timbers bolted to the tops of the journal boxes at each end of the axles. On top of these timbers other 12x12-in. timbers were laid crossways, in such position that any load coming on them would be distributed equally among the three axles. On top of these again, two 8x16-in. timbers were placed on each side, they in turn carrying two 12x12-in. timbers and the small blocking for supporting the bridge. Two of these trucks were placed under each corner of each span, making eight trucks under each span. The trucks were placed under the centers of the stringers in the first (end) and second panels of the trusses and blocked up under the stringers (Figs. 9 and 10).

The weight of the entire bridge to be moved was 1500 tons, or 500 tons per span, making a load of 21 tons per axle, if uniformly distributed. The flexible construction of the trucks and their location with reference to the weight of the steel, made it practically impossible for any one axle to

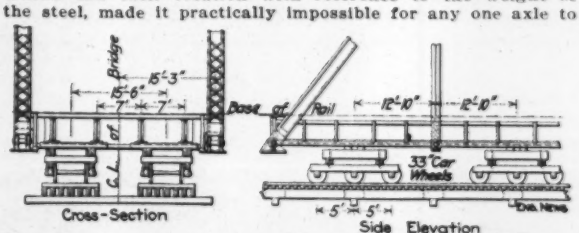

FIG. 9. ARRANGEMENT OF TRUCKS UNDER THE BRIDGE SPANS FOR MOVING THE SPANS LONGITUDINALLY 123 FT.

carry double that load, but it was thought that there might be an increase of about 50% on any one truck, bringing 30 tons on an axle. The weight of a 50-ton coal car fully loaded is nearly 80 tons, which is 20 tons static load on each axle. But this load is increased 50 to 100% by impact while wheels are passing over joints and special track appliances, making a load of 30 to 40 tons, and as the axles and wheels had already been tried out in service, no fears were felt in regard to loads of 30 tons or slightly higher during the rolling of the bridge, especially as that load would have no impact.

A few days before the bridge was ready to be moved longitudinally the trusses were jacked up and the rails and rollers which had been used for the side movement were removed and replaced by means of sand-jacks. Each sand-jack (Fig. 11) consisted of a box 10 in. high, with four sides and top and bottom composed of 3x10 in. lumber held together by ¾-in. bolts. The floor of the box was larger than the frame and the frame was made slightly larger than the truss shoes. The top was composed of a number of loose pieces of 3x10-in. lumber, just the right length and width to fit within the sides. Each box was filled level with sand and the cover placed on top of it before the truss shoes were let down carefully on the covers so as to miss the sides. These sand jacks carried traffic a number of days while preparations for moving were being made.

As an anchorage for the longitudinal movement, several heavy bridge timbers had been buried behind the east abutment and both ends of a 1-in. cable led from the deadman to the back wall of the abutment. Two sheaves were attached to the projecting ends of these cables. Two other sheaves were attached to the floor beam at the first panel point from the east end. The lines were run through these sheaves to form a nine-part ⅝-in. steel cable on one side and a four-part 1¼-in. manila rope on the other side. The lead lines were run to drums on hoisting engines mounted on flat cars anchored to the bridge (Fig. 12).

The sheaves were attached to the east span only. It was thought that the rails would be sufficient to pull the middle and west spans, but as an additional precaution 12x⅝-in. plates were bolted to the tops of the brackets that projected beyond the end floor beams of the spans over the piers, making a connection which in effect formed a continuous steel structure 540 ft. long.

On the morning of April 19, everything was in readiness for the longitudinal movement. At 10:25 a.m., traffic over the bridge was suspended and after placing the hoisting engines, the tracks at the ends of the bridge were cut. Blocking as tight as could be placed by hand was placed between the steel stringers and the tops of the trucks. Then the bolts holding together the sides of the sand-jacks were taken out and the sand removed from under the shoes, letting the spans down gently onto the trucks. The application of the weight for the first time to the trucks and the falsework caused a total settlement of the spans of about 3 in., leaving about 7 in. clearance under the truss shoes. Fig. 12 shows the bridge ready to move, and the derrick car at the right is removing the trestle approach to permit of hauling the bridge forward.

The weight of traffic on the sand-jacks had so thoroughly compacted the sand that after the sides of the jacks were removed the sand held up the load until it was scraped out from under the shoes. While the sand-jacks were being removed, a derrick car removed the 125 ft. of temporary frame trestle at the east. Then the bridge was ready to be moved.

A simultaneous pull on all the lines was not sufficient to overcome the inertia of the bridge, and the heavy pull broke the deadman cable. A new hitch was taken on it by digging down a short distance. Jacks were distributed and set at an angle at various points under the shoes, and a locomotive was set to push against a strut on the floor beam at the west end. Simultaneous application of all the power started the bridge, and it rolled 123 ft. to the new piers in about three minutes.

In arranging for the longitudinal movement, provision was made for settlement of the falsework of about 4 in., which it was thought would be ample. Later developments indicated that the settlement amounted to practically nothing, but difficulty was encountered from another cause which was not anticipated. During the construction of the falsework, cutoffs for the piles were given by level. It developed during the moving, however, that some piles had been cut off lower than others and the falsework had a wavy upper surface, which was not noticed.

The trucks supporting one corner of a span before movement rested on a high point in the false work and during movement rolled to a lower point, causing the shoe at the end of the span to drop down sufficiently to interfere about ½ in. with the top of the new concrete pier which it should have cleared by about 3 in. For this reason the movement of the bridge was stopped when within about 3 ft. of its final location and work was delayed until the I-beam grillage attached to the bottom of the shoe at this corner was removed, after which the bridge was readily rolled to final position.

After the spans reached the new piers, wedges were driven under the shoes to carry traffic temporarily and the weight was not otherwise removed from the trucks, as it was thought that the deflection in the end panels over the trucks on which the bridge rolled would meet with such elasticity in the timber blocking on the trucks as to cause no damage. Within the next few days each of the spans was jacked over, placed in final position, and the weight removed from the trucks.

It had been the intention to fill the gap at the west end of the bridge by setting frame bents and timber trestle on the false work over which the bridge had rolled. But on account of the frequent interference that would have resulted while changing out the trestle for the erection of the new steel floor under traffic, arrangements were made with the operating department to keep the bridge out of service until the steel floor (for the additional span) was placed. The steel was previously loaded on a barge and raised from there to position by a derrick car.

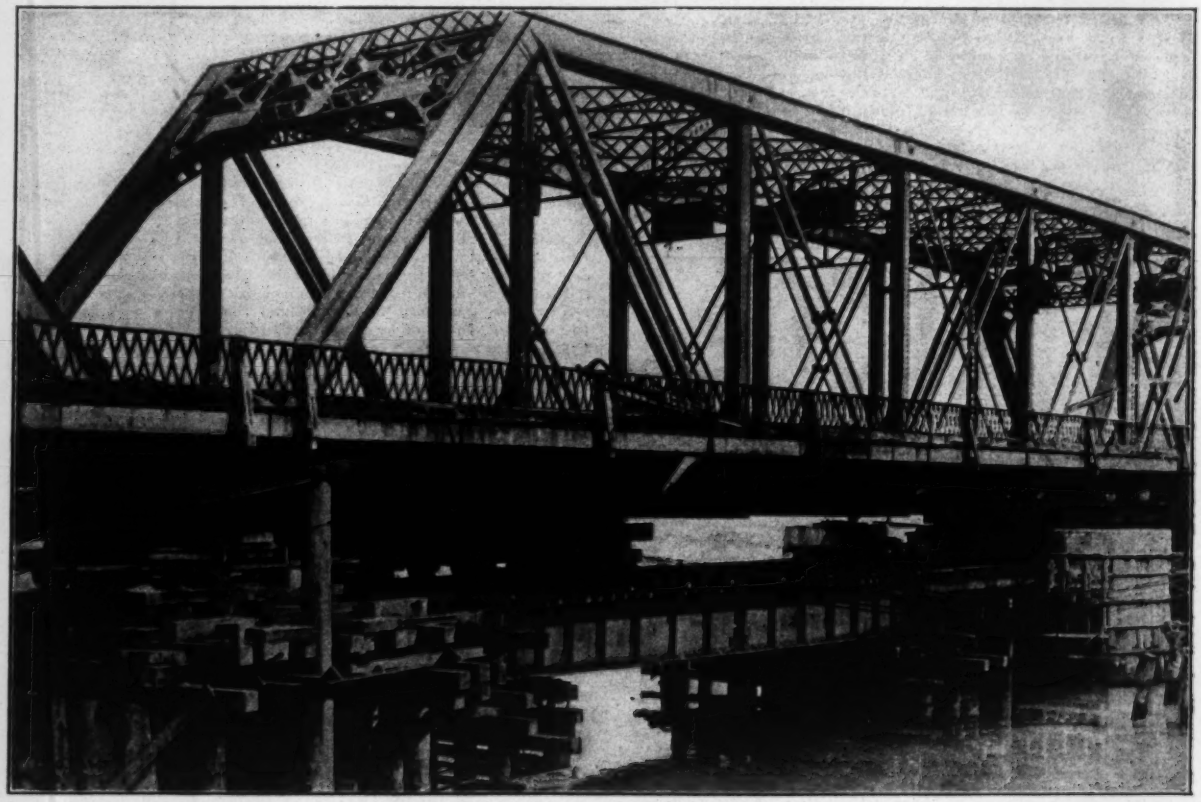

FIG. 10. THE SPANS RAISED AND SUPPORTED ON TRUCKS READY FOR LONGITUDINAL MOVEMENT

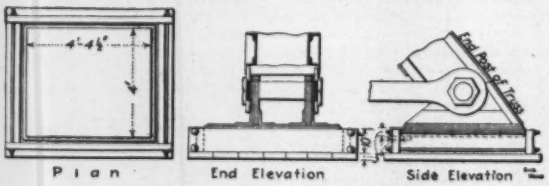

FIG. 11. SAND JACKS FOR SUPPORTING THE BRIDGE TRUSSES ON BLOCKING AND LOWERING THEM UPON THE TRUCKS READY FOR MOVEMENT

The longitudinal movement consumed more time than was anticipated. Track was cut at 10:25 a.m. The removal of falsework at the east end, letting down the 12 sand-jacks and moving the bridge endways consumed about 3 hr. The afternoon was taken up in setting the blocking and steel floor system for the new span to be erected at the west end of the bridge. Track was connected up again at 8:15 p.m.

CLEARING THE CHANNEL

The erection of the new span at the west end followed immediately. In the meantime the falsework was removed with almost feverish haste from the main channels, the deck girders being removed first, as the Kaw River has a bad reputation of coming down with great floods in May. The flood of March proved to be the worst of the spring, however, and there was no flood in May or June. All falsework piles were pulled out by the derrick cars.

The foundation work had been temporarily suspended for about one month while the bridge was being moved to the new piers. After this had been accomplished the work of removing the old piers was started. The cut-stone masonry

COST OF RECONSTRUCTION OF KAW RIVER BRIDGE; MISSOURI PACIFIC RY.

Two abutments:			
4000 cu.yd. excavation	$6.03	$24,110	
7040 lin.ft. piles	1.31	9,230	
1520 cu.yd. concrete	9.51	14,150	
Total for abutments			$47,490
Three piers:			
3100 cu.yd. excavation	$9.02	$27,950	
8960 lin.ft. piles	1.54	13,840	
3500 cu.yd. concrete	7.35	25,730	
Total for piers			$67,520
Removing old foundations and clearing channel to specified level			32,500
Raising and moving three old spans, 1500 tons, at $20			30,000
New 196-ft. span, 440 tons, at $70			30,800
Raising 12 miles of yard tracks and making necessary track changes			166,690
Total cost of improvement			$375,000

was very easily taken down to the water level. Then holes were drilled in the piers and they were broken up by dynamite, the broken masonry being dredged by clam-shell buckets. Then followed the removal of the footing courses (into which the foundation piles projected 8 ft.), the foundation piles, and the riprap surrounding the piers. The remainder of the old bridge iron, cars, car trucks, rails and other débris of every sort was then removed down to 15 ft. below low water, carloads of scrap iron being loaded and shipped.

This cleaning out of the channel consumed about six months and necessitated frequent use of dynamite and divers.

FIG. 12. HAULING THE MISSOURI PACIFIC RY. BRIDGE SPANS A DISTANCE OF 123 FT. ON FALSEWORK TO ITS POSITION ON THE NEW PIERS

At one time five pin joints of an old Union Pacific truss, with all truss members, floors beams and bracing attached, were raised from the river bed and suspended from the Missouri Pacific bridge, other members extending down into the river bed. A heavy pull by a 100-ton steam wrecking crane failed to loosen up the parts below the water, however, and they were shot off as low as possible by dynamite placed by the diver. The removal of much of the débris necessitated the dredging of deep holes far below the required depth of dredging. The work was continued, however, until all obstructions in the entire width of river were removed to the specified level.

Preservative Treatment of Poles*

BY RUSSELL A. GRIFFIN†

The most perfect method of timber preservation is the injection of coal-tar creosote or dead-oil of coal tar. This is done in three ways: (1) By the closed-tank pressure method, (2) by the open-tank method, and (3) by application with a brush.

CLOSED-CYLINDER TREATMENT

In 1897, while in the service of the American Telephone & Telegraph Co., I arranged for the purchase of some 10,000 creosoted yellow-pine poles for a line which was built that year from Washington to Norfolk, Va. These poles were treated their entire length by the closed-cylinder pressure process under a specification requiring the injection of 12 lb. of dead-oil per cu.ft. A recent inspection of this line showed it to be in a practically perfect state of preservation. These same poles, if untreated would have served their usefulness in about four years, as yellow-pine rots very rapidly in the ground.

In spite of the excellent results that have been obtained both here and abroad by the full-cylinder treatment, the proportion of poles thus treated has been relatively small. This method has been resorted to principally in the South, where, on account of the climate and soil conditions, exceptionally rapid decay makes a preservative treatment almost essential. The chief hindrances to a more general adoption of this method for treatment of poles have been the high cost of the treatment and the expense of the transportation of the poles to a treating plant.

Recent investigations have been conducted mostly with cheaper and simpler methods, and with treatments which could be applied locally by the consumer, or at the large cedar pole yards. Approximately 60% of the poles in use are cedar, and about 20% chestnut, and these woods lend themselves readily to the method of partial treatment described below.

BRUSH TREATMENT

The brush treatment consists in painting the pole with a preservative, preferably creosote oil. The portion of the pole most subject to decay is just below and just above the ground line. Therefore the pole should be painted about 2 ft. below and 2 ft. above the ground line. Only seasoned poles should be treated, and care should be taken to see that the wood is thoroughly dry before the treatment is applied.

It is decidedly preferable that the preservative should be heated to a temperature of 150 to 175° F., and distinctly better results will be obtained from two coats rather than one coat. Particular attention should be paid to the filling of all checks and knot holes, and to working the preservatives well into the wood. An average 30-ft. pole will absorb, by this treatment, about 4 lb. (½ gal.) of oil, and if treated under proper conditions a penetration ranging from $\frac{1}{16}$ to $\frac{1}{8}$ in. can be secured. Brush treating can be applied with ease in any locality, on along the route of a line in the process of construction.

It is a very economical method. In 1911, the American Telephone & Telegraph Co. treated 12,000 poles with creosote oil by this method in Nebraska, at a cost of approximately 25c. per pole. This cost included the cost of the oil and labor. Previous reports of experiments in brush treating estimated an increased life of from two to three years, but these estimates will be substantially exceeded, if not doubled. The depth of penetration is comparatively slight, but experience has shown that the protection afforded by the brush treatment is usually destroyed through mechanical impairment, rather than through loss of the preservative by volatilization or leaching, provided always that the material used for treatment is one of the oils known to possess good antiseptic properties.

OPEN TANK TREATMENT

Treatment by this method consists in placing the butt end of the pole in a tank into which an antiseptic preservative (preferably dead-oil of coal tar or carbolineum) is poured until the poles are covered for a distance of about 8 ft., or to a point equivalent to 2 ft. above the ground line.

The oil should then be heated to a temperature above the boiling point of water, and this temperature maintained until the air in the wood has been expanded and the water in the outer layers vaporized and both driven out as far as possible. In other words, the high temperature should be maintained until bubbles cease to appear on the surface of the oil. The oil should then be permitted to cool, or the poles transferred to another tank containing cold oil. A partial vacuum is thus produced by the contraction of the air and the condensation of the moisture remaining in the wood, and the preservative is forced under atmospheric pressure into the wood. A treatment by the method described consumes about 24 hours, during which the pole is subjected to the hot oil from 8 to 9 hours.

In 1905, the American Telephone & Telegraph Co. treated by this method and by the brush method 600 chestnut poles, which were set that same year between Warren, Penn., and Buffalo, N. Y. The balance of the poles in this line were untreated, part green and part seasoned. The treatment was made in conjunction with representatives of the U. S. Forestry Department, and various preservatives were used. An inspection of this line made three years ago (five years subsequent to its erection) developed the fact that 100% of the green, untreated poles showed an average loss of circumference at the ground line from decay of 1.16 in., 99% of the seasoned, untreated poles showed an average loss of 1 inch.

Of the brush-treated poles, decidedly the best results were obtained from those treated with coal-tar creosote and carbolineum. Decay had commenced sooner and developed

*Abstract of a paper read at the annual convention of the National Electric Light Association, at Chicago, June 3-6.

†Western Electric Co., Chicago.

much more rapidly in the poles brush-treated with other preservatives. Only 14% of the poles brush-treated with the coal-tar creosote oils showed any sign of decay and the average loss in circumference of those in which decay had started was from 0.02 to 0.04 inch.

The inspection further disclosed the fact that every pole which had received the open-tank treatment described above was in a perfect state of preservation. This would seem to be ample demonstration of the efficiency of the treatment. The greater depth of penetration obtained in the open-tank treatment (approximately two to four times the depth obtained in the best and most careful brush treatment) justifies the expectation that mechanical impairment and damage from checks will not play so important a part in connection with the initiation of decay as in the case of brush-treated poles.

It should be thoroughly understood, however, that the results from an open-tank treatment, such as is described and from which a thorough impregnation is secured, will be much superior to the results which may be expected from a short-period dipping treatment which has been termed an "open-tank treatment." If not properly performed, the open-tank treatment will not give a penetration appreciably different from that obtained in a two-coat brush treatment. And it may be considered that a short-period dipping treatment can be ranked as about equivalent to brush treatments.

The Montreal Tunnel and Terminal

By S. P. Brown*

SYNOPSIS—One of the most remarkable feats in railway construction and railway development ever recorded has been the creation of the Canadian Northern Railway System. A dozen years ago the Grand Trunk and Canadian Pacific controlled nearly the entire railway system of Canada. There seemed no possibility that a new competitor could arise to compete with these great and powerful companies. From comparatively small beginnings, however, the Canadian Northern system has grown at such a phenomenal rate that it now has nearly 5000 miles of railway in operation and 2500 miles additional under construction. At present, the system comprises two widely separated groups of lines in the eastern and western provinces, but construction is well advanced upon the connecting line which will link these up into one homogeneous and comprehensive system. In view of this development the railway will require extensive terminal facilities at Montreal, and in order to secure a direct and convenient entrance to that city a 3-mile tunnel is being driven through Mount Royal, the mountain which dominates Montreal Island and gives its name to the city. This tunnel is of special interest from its section and its length and especially for the phenomenal speed with which it has been driven.

The Canadian Northern Ry. is now at work on the new tunnel and terminal developments for its entry into Montreal. This railway has about 2500 miles of line under contract, which, when completed, will unite the bulk of its lines into a transcontinental system, with an outlet in Vancouver, in the West, and with Montreal as its main eastern port.

It must be remembered that, besides its eastern lines, the Canadian Northern Ry. has about 5000 miles in operation in the West, tapping probably the most fertile grain territory on the continent. The wonderful productiveness of this country, which owes its phenomenally rapid growth primarily to its railway development, is well illustrated by the fact that every western line of the Canadian Northern Ry. has paid the interest on its bonds the first year of operation.

The Montreal Terminal

In view of the fact that this great network of tracks, with the various allied interests, will be tied into its transcontinental form some time in 1914, it is imperative that proper terminal facilities be provided in the main enstern terminal point, which is also the metropolis of Canada and its principal Atlantic seaport during the busiest part of the year. With this in view the Canadian Northern Montreal Tunnel & Terminal Co. was incorporated under a Dominion charter, for the purpose of building these terminal works and leasing them to the Canadian Northern Ry.

Montreal has a population of about 600,000, a large portion of which is French. It is situated on the island of Montreal, formed by the St. Lawrence and Ottawa (Back) Rivers, which is at the head of the natural navigation and at the outlet of the Lachine Canal and the proposed Georgian Bay Ship Canal. The business and central part of town is located on a comparatively narrow strip between the St. Lawrence River and Mount Royal. This mountain, rising in the middle of the city proper, forms a decided barrier between the people living at the back of the mountain, in Outremont and Westmount, and this business section of the city. This narrow strip of land comprises two levels, the commercial and financial district being on the lower level, only a few feet above high water; and the retail, hotel and residential section being on a plateau about 75 ft. above the river. The situation is explained by the plan and profile in Fig. 1.

To have entered this narrow strip from the ends would have meant long detours, and possibly two separate stations for eastbound and westbound traffic, which would have been decidedly undesirable. Furthermore, the construction would have been complicated and expensive in many ways.

A study of the topographic and economic distribution of the city and island showed that a direct tunnel line was the logical method of entry. It was found that the western lines could be brought to a convenient site for transfer, sorting and storage yards, with shops and other auxiliaries, near the Back River, and could connect directly with similar (although less elaborate) yards for the eastern lines near the lower end of the city. These yards will also be the electrical transfer points for both freight and passenger service as all railway service within the city will be electrified.

From the western yards, the main entry crosses the Jacques Cartier Union (Grand Trunk) Ry., about three miles west of the city limits. From this crossing the line is depressed through the site of a new city, designed for 50,000 people, and forming a part of the Canadian Northern Ry. project. This line passes out of the new city site into the city of Montreal, close to the western

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portal of the tunnel, which is located at its crossing of the Canadian Pacific Ry. belt line, about a mile from its Outremont yard.

The tunnel is designed for two tracks in two separate tubes, for purposes of ventilation, safety and economy of construction. It runs down from its western portal at a grade of 0.6% for 3.25 miles to a main passenger terminal located in the very center of the business portion of Montreal.

The Terminal Station

This passenger station will be located between the two levels of the city (noted above), being thus ideally placed for every class of passenger traffic. The tracks will be at such a level as to make its platforms and bridge level very conveniently accessible by ramps and driveways from any quarter. This arrangement is of particular value to commuters, as well as for the convenient handling of baggage and express. It is, furthermore, planned to have it so arranged that the express and suburban passengers will segregate themselves automatically.

It is seldom that a freight delivery station can be located economically in the very center of an important city. Too little attention has been paid to this branch of the business in many of the terminal developments recently produced, and as the bulk of a railway's revenue comes through its freight, efforts are being made to produce a freight-handling system of the most efficient character.

The idea of the whole terminal development is utilitarian. While the terminal structures will form one of the most architecturally attractive groups of buildings in Canada, they are also so designed and disposed as to produce a revenue that would make the whole investment self-supporting without considering the profits from the railway business.

Geological Conditions of the Tunnel

Mount Royal is a volcanic intrusion of igneous rock, forced upwards through the original bed of Trenton limestone. Whether it was ever an active volcano is doubtful as there is little evidence of lava, although this may

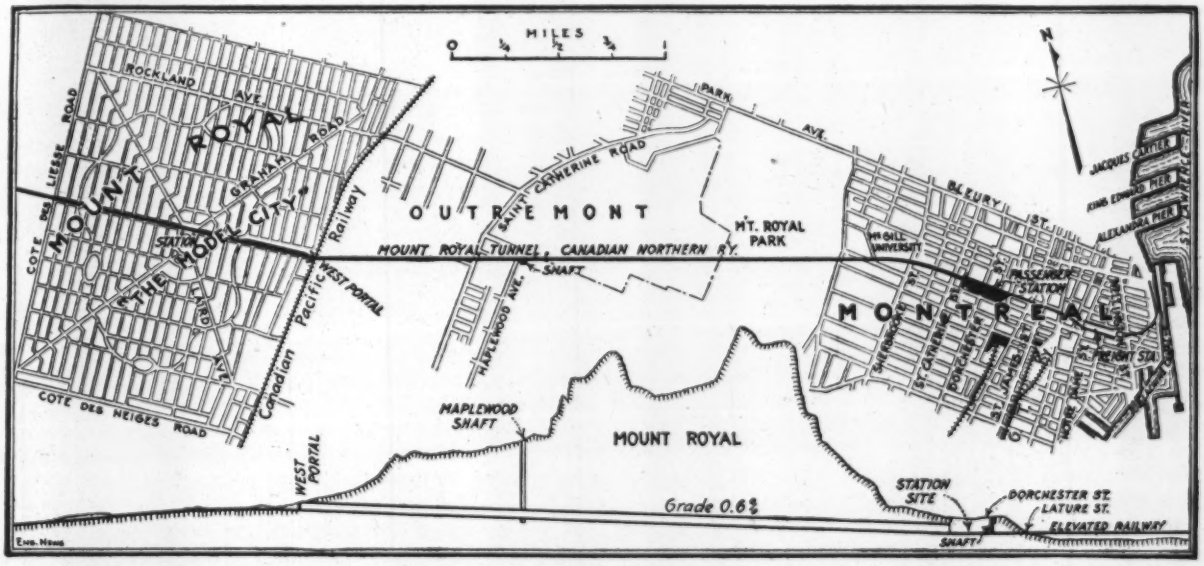

Fig. 1. Plan and Profile of the Montreal Tunnel and Terminal, Canadian Northern Ry.

From the main passenger station the tracks may be extended across the lower town, on an elevated viaduct at a level grade, to connect with the Harbor Commissioners' proposed viaduct along the river front. This arrangement would give direct access to the Canadian Northern Quebec Ry. lines east, the Canadian Northern Steamship Line and all harbor facilities. It would also give direct connection with a proposed bridge across the St. Lawrence River (at St. Helen's island) to bring eastern and southern railways into the city of Montreal.

As a part of the proposed viaduct across the lower town, there would be a freight station situated in the center of the commercial district, for the receipt and delivery of local freight. This would be purely for loading and unloading; all the sorting, switching and transfer business being handled in the east and west yards outside the city proper.

In this connection rather exhaustive studies are being made for the rapid and economical handling of freight, as it is purposed to make a feature of this department.

have been scoured away by glacial action, at the same time that the higher portions of the mountain were similarly eroded. There have evidently been several stages of eruption or intrusion, as both the limestone and main igneous body of so called Essexite are broken and cut by a multitude of dikes and sheets of quite different character and evidently later origin. The Trenton limestone, at a considerable depth, is found to be hard and crystalline, and (except where siliceous limestone is encountered) it is an excellent rock for tunneling.

At the city end, going west from Dorchester St., the heading for the first 2000 ft. was in a soft black limestone, somewhat blocky and in places partially disintegrated, with occasional stretches of earth roof. As the rock cover increased, this rock became harder, and more dikes of extremely hard igneous rock were encountered. By the time 3000 ft. had been driven, the heading (except for the dikes) was in good sound Trenton limestone, which is becoming more crystalline.

The Essexite is very hard and high in iron, containing

a good deal of nepheline and hornblende, so that it is extremely difficult to drill. Aside from this it is a good tunneling rock. The most difficult tunneling rock encountered is the siliceous limestone and a volcanic breccia. Both of these are usually cut by a great number of dykes, and so badly broken and blocky that they are extremely hard to drill, do not shoot well, and will probably require almost continuous masonry lining. The breccia, which is the most difficult rock to contend with, is quite common to the contact between the limestone and the main volcanic intrusions.

Tunnel Progress

A good illustration of the effect of this character of ground on tunnel progress was illustrated in the heading going east from the west portal. In the limestone, which was a free drilling rock for the first 1500 ft., the rate

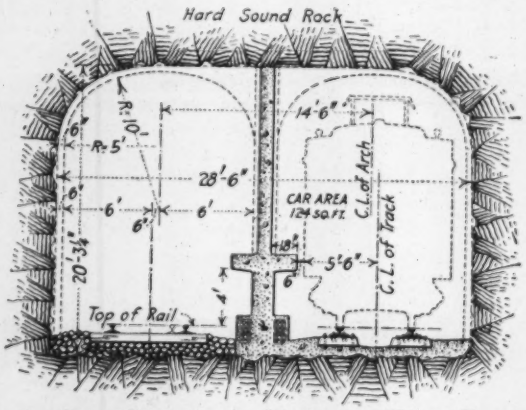

Fig. 2. Cross-Section of Montreal Twin Tunnel in Hard Sound Rock

(Rock excavation, 21.8 cu.yd. per lin.ft. Concrete, 1.05 cu.yd. per lin.ft. Area, inside, 272.47 sq.ft. Area inside theoretical arch, 243 sq.ft.)

of progress steadily increased, as the men worked into the methods of excavation adopted, until they were making an average of 22 ft. per day. When the breccia was encountered, this progress dropped to 9 to 12 ft. per day, nor was it materially improved until the character of the ground had changed.

In the hard crystalline limestone the average heading progress, without drill carriage, was about 18 ft. per day. When the crystalline limestone came in close proximity to the large igneous body, the dikes became very much larger and more numerous so that the progress dropped to about 13 ft. per day, in spite of much heavier drills which had been installed. At this point a drill carriage was installed and the average progress increased to 22 ft. per day. At the city end, in the good limestone, before becoming too crystalline, the progress averaged 26 ft. per day. What the progress will be in the solid Essexite is yet to be determined.

The average progress to date in each heading (omitting the fractional months in starting the headings) has been 400 ft. per month. In this average no allowance was made for Sundays, holidays or delays. Over 2000 ft. was in soft ground requiring timbering.

Tunnel Location

The location of the tunnel under Mount Royal was established more or less by the location of the passenger terminal in Montreal, and by the "model city" at the back of the mountain. For many reasons, a tangent from the central station in the "model city" to the passenger terminal in Montreal would have been most desirable. But as this would have necessitated passing under much valuable property with very light cover it was thought best to abandon it. This line would also have passed through a large body of nepheline syenite, which is a very hard rock.

It was known that the heart of the mountain was of a hard igneous rock, as above described, which, with breccia, also showed outcappings in a ridge near the western portal. While this lower ridge of hard rock and breccia could not have been avoided without seriously affecting the layout of the "model city," a portion of the hard rock in the center of the mountain could have been avoided had it been considered expedient.

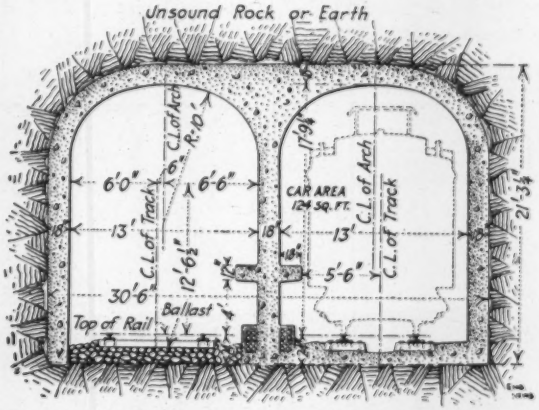

Fig. 3. Cross-Section of Montreal Twin Tunnel in Caving Rock or Earth

(Rock excavation, 23.32 cu.yd. per lin.ft. Concrete, 5.6 cu.yd. per lin.ft. Area inside arch, 243 sq.ft.)

The line finally adopted is the shortest line possible, between the two main objective points, that could be devised to avoid surface obstructions and take advantage of the geological formation, as far as it can be anticipated. It is believed that much of the breccia and part of the limestone will require masonry lining, similar to that required in soft ground. Much of the crystalline limestone, inclined as it is to the present tunnel line, will require only a center wall for safe support. In the Essexite no center wall will be required except for ventilation and for purposes of safety, in case of derailment or accident. This gives, economically, an extremely good tunnel line, which (with the exception of one curve under the McGill University grounds) is all on a tangent and has only sufficient grade to insure proper drainage.

Surveys and Alignments

The underground alignment is a little more difficult in the case of the Mount Royal tunnel than is usually the case, owing to the fact that the shafts entering the tunnel had to be sunk on company property which was off the tunnel line. This necessitated short and irregular curves with very contracted sights.

As a bottom heading is being driven, permanent monuments are placed in the bottom of the heading and only plugs and spads with occasional vernier scales are used in the roof. The shaft alignment was done with piano

wire and heavy plumb bobs suspended in water and oil.

The surface surveys were very simple, as the fact that Montreal practically encircles the mountain enabled traverses to be run around the base through the streets, thus avoiding the necessity for triangulation. While this method of survey is very simple, great care was used in the actual work with most gratifying results. The lines going west from the Maplewood shaft (about 240 ft. deep, with a 13-ft. base) met those coming east from the west portal, a mile away, when the headings were holed, within $\frac{1}{16}$ in. in alignment and $\frac{1}{4}$ in. in grade.

Cross-Section of Tunnel

The type of tunnel cross-section finally adopted, while bearing many points of similarity to various other tunnels already in existence, has a few novel features that are believed to be a step in advance in that particular branch of railway engineering. The two types of section are shown in Figs. 2 and 3.

In the studies for this design, the maximum equipments of American roads were summarized, and actual clearance and equipment diagrams of many of the most representative roads were studied and superimposed. In this manner a diagram of minimum clearance and a diagram for maximum equipment were evolved, for all cars likely to pass through the tunnel. It was found that a few freak cars, of exceptional width, had to be eliminated, but these were very few, of a class not likely ever to appear, and which had not been allowed for on other important roads.

A twin section was chosen for three primary reasons: (1) economy in construction; (2) ease and economy in ventilation; and (3) protection and safety in case of derailment or accident.

1. Economy in Construction. It was found that in soft ground the amount of both excavation and masonry could be reduced by adopting this twin section. The geological formation also indicates that in much of the limestone, cut at the angle made by the present tunnel location, a center wall will sufficiently reinforce the natural rock roof slab to eliminate the necessity of further lining without excavating a high rock arch.

2. Ventilation. It is needless to say that a twin tunnel with all the traffic in each tube moving in the same direction, is infinitely better for ventilation, than a double-track tunnel, where passing trains merely tend to stir up the air, without causing any positive and continuous movement. The cross-section of each tube is so proportioned that the relation of train area to tube area will materially encourage ventilation, without producing excessive compression, which would retard the velocity of trains and be objectionable to passengers.

3. Safety. The center wall is particularly valuable in case of derailment or accident, there being no possibility of trouble on one track blocking both tracks. Furthermore, having a walkway at about the platform level, it is possible for passengers to get out of the cars, in natural and orderly fashion, in case of stoppage, and walk to the nearest cross passage, where they can enter the adjoining tube. This walkway is made narrow, so that people must pass along it in single file, the idea being to avoid the danger of crushing and panic.

The normal clearance at the walkway edge is 2 in. greater than that of the normal high passenger platform adopted in the terminal station, and 3 in. greater than that allowed on the New York Central R.R. and Pennsylvania R.R. lines about New York. The walkway edge also coincides with the clearance lines (outside of platform) of the Pennsylvania R.R. (lines east of Pittsburgh), including the through lines between New York and Pittsburgh.

Underneath the walkway is a continuous refuge niche, except at splicing chambers, where trackmen may sit on the duct bench, at the bottom of the dividing wall, and be absolutely protected from passing trains. Large refuge niches will be built occasionally in the outside wall, for the accommodation of hand-cars and repair equipment during hours of train operation. The outside wall clearance is coincident with the clearance for new structures in the New York Central R.R. terminal work in New York, and is in excess of the clearance of the Pennsylvania R.R. lines east of Pittsburgh.

A high headroom was adopted on account of provision for a high-voltage trolley. The flattened three-center arch was adopted: (1) to allow for the sway of the pantograph; and (2) on account of the stratification of the rock, where much of the lining will occur, which lends itself peculiarly to a flat roof, as mentioned above.

The floor and track construction will be of two types: (1) creosoted ties, with tie-plates and screw spikes, laid in a deep trough on ballast; (2) a fixed grade and alignment, produced by rail supports rigidly fastened in a concrete bed. The former, used under the city proper, is designed to produce the least possible vibration. The latter type, being for stations and in the major part of the tunnel, is designed for small maintenance cost with perfect grade and alignment.

The general cross-section, as above described, will vary materially, in certain details, with the character of the ground through which the tunnel passes. Where lateral pressures are encountered, the side walls will be somewhat arched against it. Where the roof is bad and the sides are in good rock, the side-wall concrete will be omitted. It is believed that this design thus gives greater flexibility for economy than could be obtained by any other combination.

Tunnel Excavation

As time is of vital importance it was decided to have a bottom center heading which could be driven ahead rapidly, without much regard for the character of the ground, and from which the full-sized excavation could be developed at as many places simultaneously as desired.

The headings are driven 8 or 10 ft. high by 12 ft. wide (50% larger than the headings of the principal Alpine tunnels) for the sake of ultimate economy. While this somewhat reduces the rate of progress, it very much decreases the cost of further excavation and construction, by permitting reasonably broad-gage double track through the break-ups. Back of the mountain, where the drill carriage is working in the very hard ground, the heading is carried about 10x12.5 ft., and the progress during the month of May was 510 ft. in 27 working days. This is very remarkable considering the hardness of the rock and the number and size of hard igneous dikes encountered. At the city end the cross-section was reduced to about 8x12 ft. for the sake of rapid progress.

The bottom heading and a "break-up," where the full-sized section is developed are shown in Fig. 4. Jumbo timbers are framed into the headings at the break-ups, as

shown, so that the excavation may be stoped down onto them and dropped directly into the cars in the heading without interfering with the regular traffic. This is very cheap and rapid work, as no top heading is required, and practically no shoveling is necessary to run the muck through the jumbo timbers. It is expected to remove the bench below the jumbo timber level, on each side of the heading, with a steam shovel, after the stoping is completed.

The methods thus outlined are working out very satisfactorily. The first heading was started on July 8, 1912, at the west portal. Since that date an intermediate shaft 240 ft. deep has been sunk at Maplewood Ave., a shaft 55 ft. deep at Dorchester St., now acting as the eastern portal, and over two miles of heading has been driven on the actual tunnel line, besides more than ¼ mile of heading at the shafts and in the terminal site.

The best progress to date was made in the 31 working days from May 1, when 810 ft. of 8x12-ft. heading was driven going west from Dorchester St. The writer believes that this is a new record in hard-rock tunneling. Fig. 5 shows the heading in which this progress was made. The smaller hose are the water connections to the drills. Greater progress was made in the Loetschberg tunnel, in Switzerland, where 1013 ft. of heading 6.5x10 ft. was driven in one month, through soft triassic limestone, somewhat similar to the soft limestone encountered near the Dorchester St. shaft in the Mount Royal tunnel, as described above. Another excellent record was made during 1912, in the mines of the Arizona Copper Co., where 799 ft. of heading 8x8 ft. was driven in 31 working days in granite porphyry sufficiently hard to drill well, and in general, stand without timbering.

The character of the rock excavated from the Mount Royal tunnel is evinced by the fact that all the rock from the tunnel excavation, at both ends, is being crushed and sold (principally in Montreal) for massive and reinforced concrete work, except what is used by the company itself. At Dorchester St., the company has sublet the crushing, but at the west portal, where the major part of the excavation will be handled, it has erected a very complete crushing plant.

While neither the rock mentioned in the Loetschberg tunnel or in the Arizona copper mine can be compared in hardness with the Trenton limestone of Mount Royal, yet, as the Loetschberg tunnel rock was sufficiently hard

FIG. 4. CONSTRUCTION OF THE MONTREAL TUNNEL

(In the center is the bottom heading, with a vertical break-up from which the full size of tunnel excavation is developed.)

to require air drills, the progress there will probably stand as a world's record for many years to come, and marks a most remarkable achievement.

Tunnel Plant

The Mount Royal drilling equipment consists of Sullivan percussive drills, so arranged that a water jet mixed with air escapes through the steel (which is hollow) into the bottom of the hole, cleaning it and laying the dust. The Hardy hand-hammer drill has given particularly good satisfaction in the rock which was not extremely hard, and for trimming and blocking, it was also used to drill the heading for a short time where very short holes were used to reduce the concussion. Horizontal bars, carrying four drills, are used in the heading and break-up entries, columns being used in the break-up ribs. The steel used for the heading where the record progress

Fig. 5. View in the Heading of the Montreal Tunnel (Heading No. I-W)

(It was in this heading that a record rate of progress was made. The air drills are using hollow steels, through which water is forced to keep the drill holes clean. The smaller hose are for the water.)

was made, was F. J. A. B., which gave excellent satisfaction. From 18 to 22 holes were drilled in the face, the side rounds being 5.5 to 6 ft. dep, and an average of 500 steels were dulled each day.

In one heading, where very hard rock has been encountered, requiring extra heavy drills, and bar, a drill carriage is used having a 20-ft. cantilever arm to support the drills. This arm is given a longitudinal movement to extend over the muck pile, and lateral and vertical movements to accommodate the heading. The carriage also has a muck conveyor to assist in loading the cars without congesting the heading. All mucking is done off steel slick sheets, and the cars are so designed that they combine spring journals, 18-in. wheels and a total height of only 40 in. Thus a mucker shovels 15 cu.yd. of muck, actually into the heading cars, in his 8-hr. shift; two shots being fired in each shift.

The locomotives are converted storage-battery motors for headings, break-ups and shunting work, with General Electric trolley locomotives for the through hauls. Both Blaisdell and Sullivan compressors are used, driven by General Electric motors. There is a compressor plant at each end of the tunnel with a capacity of 5300 cu.ft.

Engineers

The fact that Mackenzie, Mann & Co. (Limited), who are doing the work, also represent the Canadian Northern Ry., enables every advantage to be taken of existing conditions as they develop, and produce the best results with the greatest possible economy.

The staff organization, covering both design and construction, is as follows: Richard Byers, General Superintendent (West); Edward Duffy, General Superintendent (East); W. C. Lancaster, Electrical and Mechanical Engineer; H. D. Robinson, Engineer of Design; H. T. Fisher, Tunnel Engineer; J. C. K. Stuart, First Assistant Engineer. The writer is Managing Engineer for Mackenzie, Mann & Co. (Limited), and Chief Engineer of the Canadian Northern Montreal Tunnel & Terminal Co. (Limited).

Preservation and Repair of Cabin John Bridge*

For many years considerable leakage has occurred in the section of the Washington city water-supply conduit which passes through Cabin John Bridge. [Reported in January, 1911, to be 2,000,000 gal. per day.—Ed.]

In 1863, when the water-supply system was first put in service, the water was not allowed to rise high enough to fill the conduit completely, but with the increased consumption of water, however, the elevation of its surface has been raised until in recent years even the crown of the conduit has been under pressure due to a head of about 2 ft.

When first used, leakage was observed and the water was drawn off and the lower part of the conduit was plastered. In a recent attempt to stop the leaks the upper portion of the conduit was plastered. While this doubtless reduced the leakage, there was still a very noticeable flow through the joints of the lining and the masonry in cold weather. This caused disintegration of some of the masonry and an unsightly appearance as well as a considerable waste of water.

Several cracks developed in the lining of the conduit. These were kept filled with mortar, but continued to open until this feature became so serious that an appropriation was requested for placing a metal lining in the conduit. An appropriation of $35,000 for the preservation and repair of the bridge was contained in the District of Columbia appropriation act approved Mar. 2, 1911, $20,000 of which was made immediately available.

This work has all been completed and consists of a cast-iron lining through the bridge, steel tie rods across both ends, a new roadway, and a reset coping.

The lining is composed of 501 lin.ft. of cast-iron plates ¾ in. thick cast in the form of arcs of an 8-ft. circle 3 ft. wide. Six of these plates form a circle and are bolted to one another longitudinally and circumferentially through flanges cast on the plates. This form of lining is typical of many tunnel linings both in this country and abroad, and is the same as was used in the Washington Aqueduct tunnel under Rock Creek.

Between the cast-iron lining and the old brick ring the space was filled with portland-cement grout poured in through holes cut in the bridge paving. On the inside of the ring, where the flanges project 3 in. from the plates, the space was filled with concrete to form a perfectly smooth waterway. Some of this concrete was placed by hand with forming and some was placed by use of the cement gun.

Directly beneath this lining at each end of the bridge six tie rods of 1½-in. steel with turnbuckles were placed transversely through the bridge to prevent further spreading.

The old brick roadway over the bridge was replaced with one of asphalt blocks by contract for $2012.40, and in order to make this surface impervious to water it was treated with a tar preparation and screenings in the usual manner. The coping, which was badly out of alignment, was taken up and reset.

Since the installation of the lining the bridge passed through a very severe winter without leakage.

*From Report upon the Maintenance and Repair of the Washington Aqueduct, District of Columbia, by Lieut.-Col. W. C. Langfitt; Annual Report of the Chief of Engineers, 1912, Appendix DDD.

The Canadian Northern Ry.

By Henry K. Wicksteed*

SYNOPSIS—A striking feature of Canadian railways is the way in which they develop towards complete transcontinental lines, each under a single ownership and extending from the Atlantic to the Pacific. The Canadian Pacific Ry. is still the only complete line, but the government Transcontinental Ry. (in combination with the Grand Trunk Pacific Ry.) will form a second, and the Canadian Northern Ry. will be a third. Both of these latter lines are under construction and well advanced. The accompanying article describes the new line of the Canadian Northern Ry. between Montreal (on the St. Lawrence) and Port Arthur (on Lake Superior), which will link together this company's eastern and western lines, and will include a very elaborate and costly terminal system (both passenger and freight) in Montreal. Of special interest is the description of the exploration and survey work through a difficult and almost unknown and inaccessible region which lies but a comparatively short distance from busy centers of civilization.

The Canadian Northern Ry. has been doing some rather remarkable work in filling in the last links of a transcontinental railway system. For over a year it has had under contract nearly 1000 miles of main line between Montreal and Port Arthur, besides the completion of a branch of 250 miles between Toronto and Ottawa,

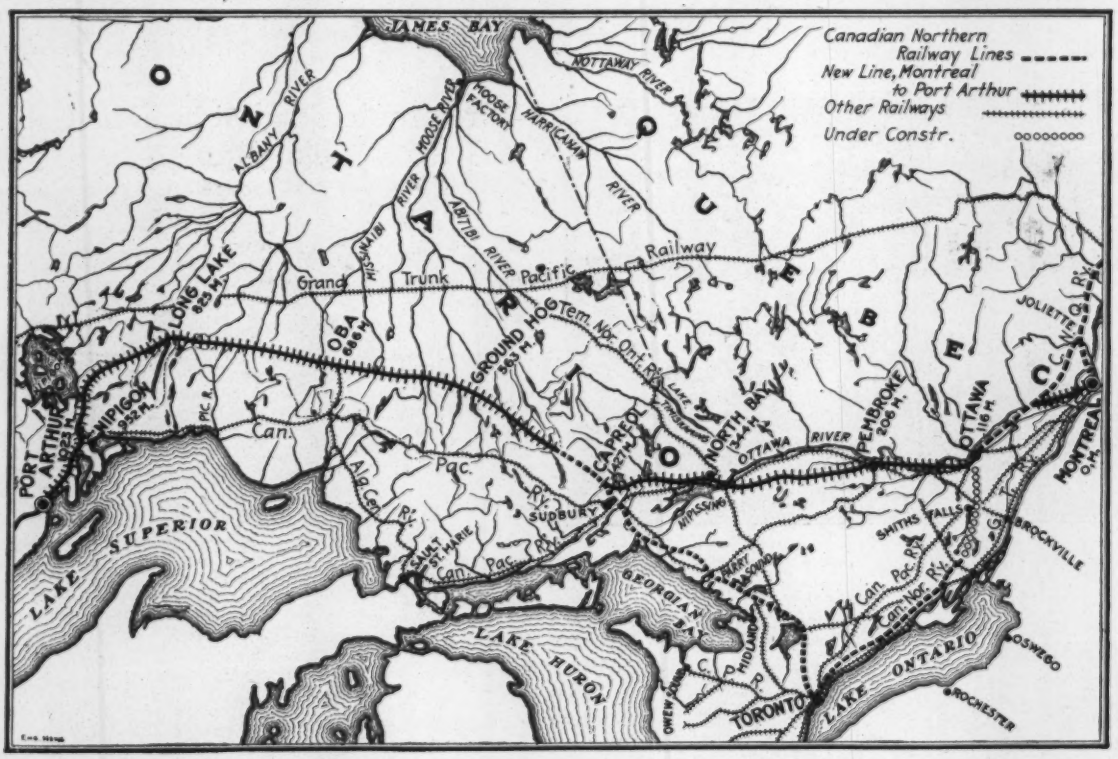

FIG. 1. MAP OF THE MONTREAL AND PORT ARTHUR LINE OF THE CANADIAN NORTHERN RY.
(This new line will connect the eastern and western lines of the C. N. Ry. System and will be an important link in its transcontinental line.)

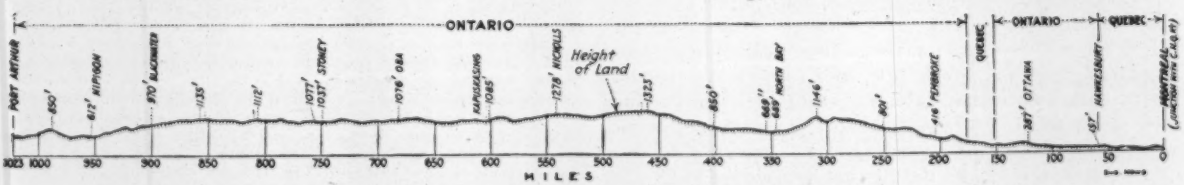

FIG. 2. PROFILE OF THE MONTREAL AND PORT ARTHUR LINE

The Canadian Northern Ry. has been doing some rather remarkable work in filling in the last links of a transcontinental railway system. For over a year it has had under contract nearly 1000 miles of main line between Montreal and Port Arthur, besides the completion of a branch of 250 miles between Toronto and Ottawa, and the construction of the Montreal tunnel and terminals, this last being the largest and boldest work of the kind which has ever been undertaken in Canada. These works are all on the east end of the railway system, between Lake Superior and the Atlantic, and independent of the line through the Rockies and down the North Thompson and Frazer rivers to the Pacific, which are not touched upon in this article.

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The Montreal and Port Arthur Line

This important link in the transcontinental system of the Canadian Northern Ry. is shown in the map, Fig. 1, while a condensed profile is given in Fig. 2.* This line (1023 miles) is not only one of the longest stretches of line to be undertaken at one time, but it is also unique in the matter of location among Canadian railways, only the government Transcontinental Ry. (now nearing completion) approaching it in the matter of ruling grades. The standard in this particular has been 0.6% against the westbound traffic and 0.4% in the opposite direction. One grade of 10 miles in length is 0.5% (compensated for curvature) against eastbound traffic, but with this single exception the standard has never been exceeded in the whole distance of 1000 miles, and not even reached except for very short distances.

Owing to the extremely rocky and broken character of much of the country traversed, no attempt has been made to flatten the curvature in the same proportion as the grades. The standard of most Canadian roads is 6°, and this has not been exceeded except in a few isolated cases. The standard obtaining for many hundreds of miles is 4° and less. In another respect the Canadian Northern Ry. is fully abreast (if not ahead) of the times; that is, the almost total abolition of grade crossings of other railways or of important highways. As a matter of fact, the securing of grade separation at reasonable cost has been a very important consideration (and at several points a governing one) in working out the location.

It will be of interest now to describe the line somewhat in detail.

Montreal to Lake Nipissing

The Canadian Northern Quebec Ry., an allied corporation, has a terminal in the east end of Montreal and runs thence northeasterly parallel to the St. Lawrence to Quebec and a number of other important points in the Province. About 1½ miles from this terminal, is located a sorting yard and a spur connecting with the tracks of the Montreal Harbor Commissioners. For economic and topographic reasons this point was chosen as the starting point for the transcontinental line. It runs thence northwest and then west, skirting in a rough semicircle the high plateau at the base of the mountain on which much of the city is built. At 10 miles it passes under the Canadian Pacific Ry.

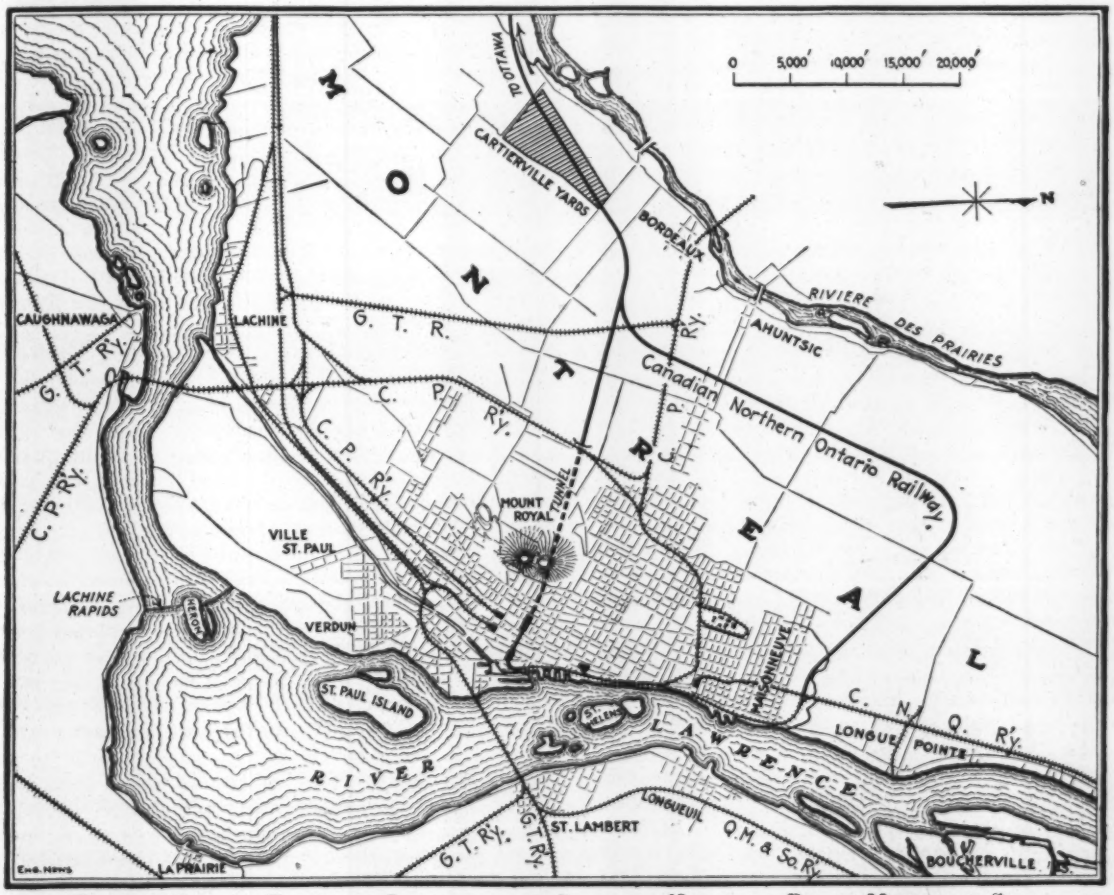


Fig. 3. Map of Terminal Lines of the Canadian Northern Ry. at Montreal, Showing the New Line with Tunnel under Mount Royal to a Central Passenger Station

*This line has been described in our issue of Nov. 9, 1911, and the map shows its relation to the Transcontinental Ry., which was described in some detail in our issue of June 27, 1912. The Canadian Northern Ry. line west of Winnipeg was described in our issue of Apr. 5, 1906.—Editor.

Half a mile further is the point of connection with the local line which will tunnel directly through Mount Royal (at its highest point) to reach the extensive passenger and freight terminals which have been laid out in the heart of the city, as mentioned above. Two miles beyond, at Cartierville, an area of 600 acres has been reserved for a divisional yard, with repair and erecting shops, and with a margin to be devoted to workmen's dwellings, etc. The Montreal terminal system (with its great tunnel) and the Cartierville yard are shown in Fig. 3.

The line now skirts the banks of the Riviere des Prairies, one of the mouths of the Ottawa, for some six miles to Mile 20, where it crosses to Isle Jesus and then skirts the east bank to Mile 22 where it crosses another channel (the Riviere des Mille Isles) and reaches the mainland near St. Eustache. The line now runs as straight as the topography will allow to Grenville, where it joins the existing line of the Canadian Northern Quebec Ry., and crosses the Ottawa with it on a fine steel bridge, 2000 ft. long, to Hawkesbury at Mile 60. It then skirts the bank of the Ottawa for nearly 50 miles more, passing through L'Original and Rockland to Ottawa at Mile 116. There are only two important bridges on this section, over the South Nation River and over Greens Creek near the city. Ottawa will be on a branch about a mile long to the existing Central Station.

The main line follows up the Rideau River and crosses it near Mile 132. The Toronto branch leaves at this point, which has been called Rideau Junction. The main line swings away again towards the Ottawa and crosses both the Canadian Pacific Ry. and Grand Trunk Ry. (Parry Sound branch) overhead, and after paralleling the river again for several miles crosses it at Mile 154 to the Quebec side. It parallels it again for 22 miles, recrossing into Ontario near Mile 176. This is the most important structure so far, necessitating a span of 300 ft. and several smaller ones. At Mile 199 it again crosses the Canadian Pacific Ry. overhead, and at Mile 206 runs into Pembroke.

So far the line has been in settled country and generally in limestone formation, following one of the great rivers of the continent for practically the entire distance. The securing of light grades has been a comparatively easy matter, but beyond this point the problem is entirely different. The line leaves the Ottawa and ascends the Indian River and almost immediately begins to rise. At Mile 225, a divide is crossed which leads to the valley of the South Petawawa (another large tributary of the Ottawa) the line skirting along Grand Lake and some other expansions to Mile 253. Another low divide is crossed into the valley of the Little Madawaska, down which the line runs to the main Petawawa. The work is quite moderate, but largely in rocks. The grades, after surmounting the Indian River divide, are almost level.

The Petawawa occupies a very marked depression running for over 100 miles parallel to the Ottawa. At points it narrows to the dimensions of a cañon, and again widens out sufficiently to form lake expansions two miles or more in width. The largest of these is Cedar Lake, 10 miles long. The scenery is very picturesque. The amount of agricultural land being very small, several hundred square miles of this and adjacent valleys have been set aside as a National Park and game preserve. The line follows the Petawawa very closely, with heavy rock work and comparatively abrupt ascents in the cañons alternating with easier country and level grades along the lake expansions, to Mile 289, where it attains an elevation of 1100 ft. above sea level.

The rise has been almost constant and although there are many miles of level there is very little reverse at any point. There is now, however, some four miles of descent to the crossing of the Kioskoqui Lake, an expansion of the Amable du Fond River. This is one of the constructive problems of the road, being 1200 ft. wide with 40 ft. of water over a not very reliable bottom of unknown depth. Eventually there will be a solid earth fill. Another divide, with an elevation of 1140 ft., occurs at Mile 306, after which there is a long descent to Lake Nipissing at North Bay, where it is 460 ft. lower. About half of this is negotiated on a grade of 0.5%, compensated; the balance is intermittent, and nowhere more than 0.4%. At Mile 339, the line again crosses the Canadian Pacific Ry. overhead, and at Mile 344 reaches North Bay, the first town since leaving Pembroke.

Lake Nipissing to Port Arthur

From North Bay the line parallels the Canadian Pacific Ry. along Lake Nipissing to Mile 359, then crosses the Sturgeon River at Mile 365 and follows its valley and that of one of its branches to Mile 397. There it crosses another low divide into the valley of the Wahnapitae, and crossing this it skirts the south shore of the lake. At Mile 427 it runs into the existing line from Toronto northward, which has been in operation for some years. This point has been named Capreol Junction.

The combined line now runs up the Vermilion valley through a country which has been proved to contain large mineral wealth. At Moose Mountain, hematite iron is being mined in considerable quantities; nickel, copper and some silver have been turned out at other points. There is also a good deal of timber being taken out at various points. The valley itself is somewhat remarkable. It cuts almost at right angles to the general strike of the country and leads up to an unusually low height-of-land between Lake Huron and Hudson Bay, 1350 ft. above the sea, at an average grade of only 10 ft. per mile. This divide is so flat as to be imperceptible to the eye, and at its highest point is a spring pond in a local depression.

For 250 miles the line has been running through a country almost useless from an agricultural point of view. Where it has not been rock, it has been dry sand and gravel, but on the northern slope of the continent it begins to improve, and some of the valleys show good land and are well timbered. At Mile 563, the line crosses the Ground-Hog, the first of the large rivers which unite further north to form the Moose River. The country is much better and shows considerable areas of clay loam. At Mile 577, the Apishkanagama (another large tributary) is crossed, and at Mile 610 the Kapuskasing Lake. This again is a very attractive country, which continues across the Missinaibi at Mile 632. Although the immediate surface is undulating, the general level is very uniform.

At Oba, Mile 686, there is one of the topographical freaks which are so common on this great plateau. A considerable stream, the Oba River, forks abruptly; part of it crosses the line and runs north into the Missinaibi, the balance turning abruptly south and after a circuitous

course crossing the line at Mile 696 as part of the Kabinakagami, which eventually empties into the Albany River many miles north of the Moose River. At Mile 712 is another large stream, the Morrison or Shekak (hitherto not laid down on the maps), noted for the size, number and voracity of its trout. Still another large stream feeding the Albany system is the Obakamiga, at Mile 740.

From this point westward the line runs into some rough Laurentian country again to Mile 800, when it again emerges onto the great northern plain near Mackays Lake. It has crossed the height-of-land in the meantime, and crosses back again near Mile 810. At Mile 825 it crosses the outlet of Long Lake known as the Kenogami River, which also swells the Albany. The lake is an extraordinary sheet of water 55 miles long, extending south to within 30 miles of Lake Superior. It formed one of the problems which the early Canadian Pacific Ry. survey encountered, and forced the line down to the immediate shore of Lake Superior. The effort to find some way round it or across it delayed the Canadian Northern Ry. surveys over a year. At the south end it is a deep valley between high granite ridges, and the country on either side is almost inconceivably rough. At the north end, on the contrary, is a flat country in every direction except south, and considerable areas of good land abut against it.

The Hudson's Bay Co. has had a trading post here for half a century or more, and within the last few years the French company, as it is called (Revillon Frères), has established another. Four long-traveled canoe routes meet here. One from the south by the lake itself and a chain of lakes and rivers connecting it with Lake Superior near Jackfish Bay. Another starting from Lake Superior by the Pic River and Mackays Lake; a third comes in from Lake Nipigon to the west, and still another follows the Kenogami River to the Albany. This point is therefore a natural gathering place for the Indians of the country and an emporium for the fur trade. The line follows approximately the third of these routes, skirting the north shore of Little Long Lake and Wild Goose Lake.

At Mile 854 it crosses the height-of-land for the fourth time and enters the basin of Lake Nipigon. Crossing the Sturgeon River at Mile 870 the line makes for the valley of a parallel stream, the Blackwater, which it follows to Mile 900. Leaving the Blackwater about five miles above its mouth, the line turns abruptly south, and at Mile 908 comes out on the immediate shore of Lake Nipigon at Sand Point. For the next 50 miles the work is generally heavy and on side-hill. The line follows the bold shore of Orient Bay, and from its head follows a curious valley between lofty trap mountains, partially filled in with glacial drift, once forming the outlet of the lake. At Mile 912 is the only tunnel since leaving Montreal, 1100 ft. in length through a bold trap bluff.

The Nipigon is crossed at Mile 945 and the line then follows its west bank to its mouth, crossing the Canadian Pacific Ry. underneath for the last time at Mile 952. Just below the mouth of the river on Nipigon Bay is a piece of construction which has given some trouble and anxiety to both the Canadian Pacific Ry. and the Canadian Northern Ry. in passing round a huge bluff 600 ft. in height fronting on Nipigon Bay. The older road has the "inside" track and is partly in cut. The new one is altogether in fill and the slopes have run out into 100 ft. of water and mud. This bluff rounded, the line leaves the bay and strikes across the head of Black Bay on very easy ground.

From Black Bay there is a long rise of 200 ft. to the dividing ridge between it and Thunder Bay. Immediately after crossing this divide is the heaviest piece of permanent trestle on the line, the crossing of Blende River at Mile 998. This is 1400 ft. in length and 140 ft. in maximum height. From this point into Port Arthur (at Mile 1023) there is a long descent on fairly easy ground to within two miles of the city whence it is being arranged to use the Canadian Pacific Ry. line to a junction with the Canadian Northern Ry. line already in operation from Port Arthur westward.

Exploration and Surveys

The surveys for this long stretch of line (1023 miles) have extended over a period of eight years, although most of the work (and that the most difficult of access) was completed in the past four years. From Montreal to Sudbury the country was fairly well mapped and had been worked over by the lumbermen. Supplies could usually be taken in by wagons within a few miles of the camps. From Capreol Junction to Lake Nipigon, on the contrary, was almost a *terra incognita*. A half-dozen of the main canoe routes had been traversed by the Geological Survey and laid down on the maps. Other information was misleading and generally worse than useless. One whole summer and parts of other summers were spent in mere exploratory work, and rough track and micrometer surveying. These established supply routes, elevations of lakes and rivers, direction of drainage, and the character of the surface geology.

From the information gained, a general route was laid down through governing points, only one or two of which have been abandoned as the result of fuller information. This being done, the regular survey was started and carried continuously forward from either end. The methods were rather different from, and it is believed an improvement on, the usual practice. The district was divided into two parts under as many experienced division engineers, probably the very best men for the task to be found in the country. To each of these was assigned two full parties, averaging from 13 to 17 men each. One of these parties ran traverses and rough exploratory lines ahead of the other and kept from 15 to 25 miles in advance of it. The other followed with trial lines and location.

The object of this was threefold. (1) The locating party should always have a knowledge of the country ahead, sufficient to prevent running into a cul-de-sac and having to back out again with much loss of time. (2) Both parties were kept on the same supply route and attended to by the same gang of packers and canoe-men. (3) Both parties could be kept in touch with one another and completely under the control of the division engineer. The plan worked on the whole remarkably well, largely on account of the personal ability and experience of the two divisional chiefs, H. T. Morrison and J. F. Rose.

The parties worked winter and summer, enough supplies being brought in during the late summer by the water routes to convenient points, at which "caches" were made, and from these they were distributed as re-

quired by dog teams to the various camps. These caches were placed as far as possible ahead of the work, rather than behind. The moral effect upon the spirits of the men owing to the feeling of security thus engendered was of marked value. As a matter of fact, there was no real privation at any time through shortage of food, practically no sickness, and very little accident. Some men mutinied at one point, tried to find their way out alone and got frostbitten and half starved; two others were drowned, but in neither case was anyone but themselves to blame. One died from the effects of alcoholic poisoning on his way in. One engineer came out of the woods to die of a disease contracted years before. These represent all the casualties.

On the other hand, the standard of comfort was maintained to practically the same level as on similar work nearer home. The tents were roomy and well heated, and the food was the best which could be obtained. A special mail carrier was attached to each division and made regular trips (by canoe in summer and on snowshoes in winter) over the 75- to 150-mile gap which separated the parties from the Canadian Pacific Ry. Fresh meat was often obtainable and fish almost always, except in midwinter.

One remarkable exception to the general standard of comfort was on an expedition organized by the western divisional engineer through an exceptionally inaccessible belt of country, which it was urgently desired to finish before the spring breakup. Mr. Rose discarded all his white staff except those absolutely necessary for the instrumental work and retained 17 Indians of the country. Tents were abandoned in favor of enough canvas to cover a wigwam. Heating and cooking were done on an open fire in the center. All the camp impedimenta and provisions were carried on the backs of the men at one trip. It is sufficient to say that in spite of temperatures lower than 50° below zero, the party emerged from the woods three months later in the best of health and spirits and with the work satisfactorily finished.

In one respect the survey parties in this north-land had a great advantage over the antarctic explorers about which so much has been heard lately. Fuel and shelter from the wind were always within reach. On the other hand the light fleecy snow of the north-land is incomparably more difficult to travel on than the wind swept wastes of the South Pole. And one is led to wonder whether the British sailor is after all the right man to carry through successfully such expeditions as that of Capt. Scott, and whether the north-country Indian or Esquimaux, under competent leadership, is not the proper person.

The half-breed runner has been known to make 100 miles in 24 hr. on snowshoes. The writer had made 70 miles, and 40 to 50 miles was an ordinary day's work a generation ago. But these men were brought up to it from childhood. No man, however strong, could hope to keep pace with them unless after years of practice. They traveled with the simplest and lightest of outfit: a rabbit-skin blanket, a sheet of cotton to keep off the wind at night, a copper teakettle, a tomahawk and a frying pan. This was the outfit, and it was such men as these who accompanied Dr. Rae to the Arctic and men of a kindred race who went north with Peary to the Pole. Nansen made one of the most remarkable journeys in history in comparative comfort because he had studied their methods and modes of life during years of residence among them.

There are still waste places on the earth to be explored and mapped and the explorers will do well to attempt merely to improve the methods which have enabled the natives to live and thrive under the local conditions, not to revolutionize them.

Equipment and Camp Outfit

The outfit of these survey parties was an interesting study in itself. The principal consideration, of course, was transportation. The northern wilderness is for the most part a hopeless jungle of growing and fallen timber, with precipitous rocks, swamps or muskegs, and lakes and rivers intersecting it in every direction. Continuous travel on foot is difficult and exhausting, and the use of pack animals impracticable. But the numerous lakes, ponds and streams afford good (though broken) navigation, and the universal means of travel in summer is the canoe. At first this was the birch-bark canoe of the native Indian, a wonderful construction built entirely of the products of the local forest, but extremely delicate and unfit for use by any but practiced white men.

Next came the basswood or cedar canoe, built roughly on the Indian models. It was much stronger and more speedy, but also heavier, and weight is a very serious matter on the portages. A still later arrival, and one coming into general use, is the canvas canoe. I believe this came originally from Maine, and it is now brought to considerable perfection. The construction, except for the canvas skin, is very like that of the Indian; but the white-man's tools and metal fastenings give him a great advantage over the native, and wonderful as the Indian's work is, considering his facilities, the civilized product is better. The canoes for the Canadian Northern Ry. surveys were built by the Chesnut Co., in Fredericton, N. B., but its models were rejected in favor of that of the aboriginal craft, and both models and construction were a decided advance on anything previously used.

Tents were also experimented with, and a number of different styles were tried. Here again lightness was essential. The final evolution was a roof of best 8-oz. duck, with back, front and walls of light drill. Shelter being almost always available and windage unimportant, the walls were made unusually high (5 to 6 ft.), adding much to available room inside.

Bedding for summer consisted of the inevitable woolen blankets, but in winter the extremely low temperatures render these insufficient for the ordinary man, even when made into a sleeping bag. The rabbit-skin blanket is the most perfect substitute which the red man or anyone else had evolved up to a few years ago, but latterly the eiderdown quilt has superseded everything else. This, made into a sleeping bag, with a protective covering of duck, has been a very satisfactory solution of the bedding question. A well fed man can sleep comfortably in a snowbank in one of these bags with the thermometer at 30° below zero.

Transport in winter is accomplished over practically the same routes as in summer, the ice on the lakes and rivers forming the road. The toboggan takes the place of the canoe. Experiments have been tried with broad-runner sleighs similar to the kometic of the Esquimaux, and under certain circumstances they are admirable. But they need a broad, open road and a fairly hard one, and

this they only get on the larger lakes. The portages are too narrow and generally too soft, and the flat narrow flexible toboggan is the only thing which is universal in its adaptation. It is generally made of the native birch and is another Indian creation which has been little improved on by the white man, although steel screws, tire bolts, and even steel wire rope have of late entered into its construction to replace the lashings of rawhide.

The hard wood gives a minimum of friction in cold weather, but towards the breakup of winter the wet snow not only makes them difficult to haul but roughens and rags up the wood. Low wooden runners, shod with steel, are then sometimes used as an adjunct, but they are awkward things to carry about during the long winter and the period of wet snow is so short that they are often omitted. Dogs are used for long-distance work and rapid traveling.

The most important part of the winter outfit is probably the snowshoe and it has been one of the hardest to get of serviceable make. The snowshoe the Indian makes for himself is good, but those he makes to sell are the reverse, and those sold by the dealers in civilization are almost useless. The Fredericton firm has taken up this branch of manufacture of late, and is supplying a very good article.

Cooking outfits have also been the subject of much study and experiment. For light flying expeditions, the open fire is all sufficient, but for a large party requiring a variety of food it is difficult in these days to find a cook who is willing to operate on one. In stormy weather his job is not an enviable one, the baking of bread especially being very difficult. Further, the open fire necessitates a very large quantity of dry wood, which is only obtainable anywhere by virtue of much chopping and hauling and sometimes not at all. In any case it takes a helper's whole time to keep the cook supplied. Sheet-steel cook stoves have been brought to a fair state of efficiency, but they are still cumbersome and heavy.

Instruments

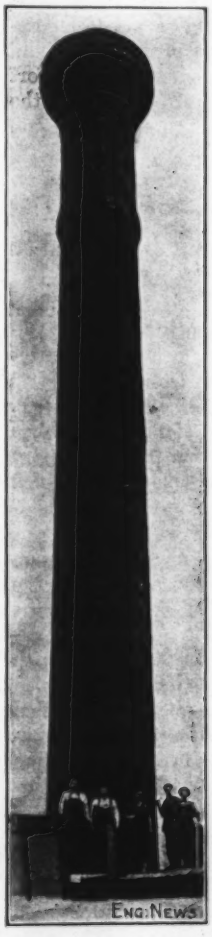
The surveying instruments would seem to be the most important of all, but as a matter of fact they caused little worry and few accidents occurred. American patterns were used almost exclusively, and the simplest and lightest were preferred. One of the worst faults with the smaller instruments was the small diameter of the milled head of the leveling and clamp screws, necessitating the removal of the mitten for every adjustment. Stadia wires or a gradienter attachment for the measurement of distances were essential, in fact much of the exploratory work has carried on by micrometric work. A vertical arc on the other hand was worse than useless, merely so much more weight to be carried.

The dumpy level was the favorite on account of the greater need for ample light than for great magnifying power. For one reason or another long sights in thick woods are seldom possible in any case, and in midwinter in these latitudes the day is only eight hours long and it is important to use the last vestige of daylight. A pole rod, self-reading, with the figures painted on the wood was used almost invariably. The telescope rods were apt to play tricks, slipping down unnoticed at times and refusing to extend when required.

Repairs were difficult to make and as a matter of fact this question of repairs with the elementary tools which could be carried (the ax, spoke-shave, auger and awl) was one that entered into consideration with almost every article of the equipment.

The Effect of a Lightning Discharge Upon a Brick Chimney

The accompanying photograph shows the devastation wrought by lightning during a heavy thunder storm which passed over Cleveland, Ohio, on the night of June 19. The chimney was 135 ft. in height, with an inside diameter of 5 ft. and served the heating plant of the two factories of M. T. Silver & Co., and also the Sunshine Cloak & Suit Co., of Cleveland. The lightning discharge struck the stack just below the brick astragal and tore out a rough channel in the side, 60 ft. in length and with a maximum width of 3 ft. A loose piece of brickwork was left hanging in the rent, just above the small opening. No lives were lost. The damages are estimated at $5000.



We are indebted for the above information, to A. D. Williams, of Cleveland, Ohio.

The Creeping of Cables, which developed within the duct lines located between the rails, within the space occupied by the old cable conduit, soon after the electrification of the old cable railway lines in Chicago, was discovered two weeks after the installation of the first cables, Dec. 9, 1907. The creeping was found to be always in the direction of the moving cars, and to be caused by the vibrations set up in the concrete by the passing cars.

In one instance a 558-ft. run of cable weighing 3800 lb. developed a longitudinal strain of 100 lb., in four days, by actual dynamometer measurement. This occurred in spite of an initial strain of 300 lb. against the direction of movement. The resultant strain was, therefore, 400 lb., or over 10% of the weight of the cable.

A break between the track and the conduit concrete, filled with sand or earth, materially reduces and sometimes eliminates the trouble. Two methods of anchoring the cables have been developed, either of which is efficacious in preventing creeping. The first is to apply a split brass clamp to the lead sheath of the cable, previously protected by several layers of friction tape. This clamp is adjusted to rest against a vertical post set in the manhole, thus creating an opposition to the thrust of the cable, caused by its tendency to creep out of the duct. The cables are held in position by being lashed to this post.

In the second method, a wooden spool, held in position by a malleable-iron clamp, is placed about the cable. The clamp is fastened to a horizontal metal bar, anchored in the walls of the manhole. The opposition of anchor to cable thrust is also the principle of this method.

This information is taken from the Fourth Annual Report on Chicago Traction, of the Board of Supervising Engineers, Chicago, Ill., for the period ending Jan. 31, 1911.

Nebraska Cities of 5000 Population and Upward may frame their own charters hereafter in accordance with a constitutional amendment adopted by a vote of about 165,000 to 32,000 in November, 1912.

Annual Meeting of the American Society for Testing Materials

(*Continued from Issue of July 3, p. 42*)

CEMENT AND CONCRETE [*Cont'd*]

TESTS OF AGGREGATES—Three papers on the tests of aggregates for concrete were presented. Russell S. Greenman (N. Y. State Engineer's Office, Albany, N. Y.), continued the report of some tests first reported two years ago to the Society, which showed the aid of certain laboratory and field tests in the selection of proper sands and gravels for general or special uses in concrete. The report gives certain tabular results to exemplify some of the principles the author thinks should govern aggregate sampling and testing.

M. O. Withey (University of Wisconsin), gave a preliminary report of results of "Tests of Mortars Made from Wisconsin Aggregates." It is a description of the technique of the tests and a résumé of some of the results that will later appear in bulletin form.

W. B. Reinke (H. S. Spackman Engineering Co., Philadelphia, Penn.), presented a paper entitled "Some Observations on the Testing of Sand," which was in effect a plea for the organization of a committee of the Society to prepare specifications for sand for use in concrete. The author urged the necessity for standard methods of testing sand and suggested in addition to the ordinary methods now generally in use in a few laboratories which do test, sand some half a dozen others which he considered necessary.

The principal one of these was a test in compression on wet mortar having the same consistency as used in the work. The author noted that in most cases, using the same cement, more water will be needed to bring a natural sand to normal consistency than is necessary with Ottawa sand, and further that the strengths obtained from a natural sand when made into a mortar of normal consistency are often equal to or greater than those obtained in the same cement using Ottawa sand. When the same natural sand and cement are made into a mortar of work consistency, which requires about 1½ times as much water as for normal consistency, the reduction of strength will be more or less marked, depending on the character of the natural sand. The strength of all sand mortars is affected by the amount of water used over that required for normal consistency. The more water used the greater will be the loss in strength at early periods. The nearer a natural sand approaches the ideal in physical and chemical composition, the less will be the loss in strength for each additional per cent. of water added. The amount of water required to bring a given sand to work consistency forms one of the best measures of the quality of sand. In mixtures using 50% more water than required to produce normal consistency, briquettes made from Ottawa sand and good, natural sand lose from 25 to 35% of their strength up to the 28-day period, while briquettes from from a poor sand may lose as much as 70 or 80% of the strength developed when made into mortars of normal consistency. Illustrating the above point the author presented a table, giving the results of a number of tests showing the effect of excess water, excess fineness and excess silica content in the sand. In conclusion he said:

In general it may be assumed that (1) the less water required to produce a mortar of a given consistency, the higher will be the strength developed by the sand; (2) the coarser the sand, other things being equal, the greater will be the strength developed; (3), the higher the silica content, other things being equal, the greater will be the strength developed; (4) where it is necessary to use sands of poor quality, loss in strength at early periods can be largely overcome by using dry concrete; (5) the loss of strength due to excess water is confined chiefly to short periods, being practically overcome with time.

It was announced that the Executive Committee would appoint a Committee on Concrete Aggregate, provided such action was agreeable to the existing Committees on Cement and Reinforced Concrete.

NEEDED TESTS FOR WATERPROOFING—Samuel T. Wagner (Philadelphia & Reading R.R.), in a paper entitled "Coal Tar and Asphalt Products for Waterproofing," suggested for a general discussion the needed specifications for the coal-tar and asphalt products which are used to waterproof masonry structures. He particularly suggested that it was not desirable to emphasize the chemical constituents of these materials, inasmuch as the average user of them is not versed in the higher chemistry necessary. He further recommended that the physical properties, which apparently are more interesting than useful to the practical engineer, should be incorporated in any tests or applications, particularly such figures as the melting point, the brittle point, the elasticity at various temperatures, the consistency. He said that at present there seems to be an impression that when exposed to air asphalt products are more durable than coal-tar products, and that the opposite is true when exposed to water, but he was not at all sure that this impression is correct.

REINFORCED-CONCRETE SLABS UNDER CONCENTRATED LOAD—A. T. Goldbeck (U. S. Office of Public Roads) described a series of tests made by that bureau to determine the behavior of reinforced-concrete slabs supported on two ends only under a concentrated load at the center. The main deduction from the tests was that the effective width of the slab is about the same as the span, a result which was confirmed in the discussion by C. T. Morris (State Eingineer of Bridges, Ohio) and W. S. Slater (University of Illinois), the latter showing a number of diagrams giving the results of similar tests he had made.

METALS

HEAT TREATMENT OF STEEL—Three papers presented to the meeting upon heat-treated steel brought out sufficient discussion to show that the effect of such treatment, taking into particular account the variation in size of the pieces treated, is not very well understood and is in need of thorough investigation.

The first paper by J. H. Nead (H. H. Franklin Mfg. Co., Syracuse, N. Y.), reported a series of tests upon the strength and ductility of heat-treated steel, such as is used in the drive shafts of automobiles. The tests were made on a chrome-vanadium steel and upon a 3½% nickel-steel. It was found for the comparatively small sizes tested (½ in. to 1¾ in. diameter) that the strength falls off uniformly with the increase in diameter, but that the ductility does not change much.

"The Influence of Mass in the Heat Treatment of Steel," by K. W. Zimmershied (General Motor Co., Detroit, Mich.), described an admittedly limited test on the properties of three pieces of steel from the same original

test bar and subjected to the same heat treatment, but machined to different diameters and length. It was found that the smaller pieces, owing to the greater effect of the annealing on a small diameter, had considerably higher tensile strength and elastic limit with slightly higher reductions of area. It was also found that the core of one of the bars had better physical properties throughout than those of the whole section, which was contrary to the investigator's previous opinion. Objection was made to the tests on the ground of the limited number of tests, but the author explained that that was admitted in the paper and that they were given only as indications, to be followed up in future work.

J. H. Hall (Taylor Iron & Steel Co., High Bridge, N. J.) showed a number of microphotographs which illustrated the effect of varying degrees of heat periods of quenching in hypo-eutectoid carbon-steel castings.

Rate of Corrosion of Metal—A. W. Carpenter (New York Central R.R.) reported further progress on the series of corrosion tests which were first described before the meeting of the Society in 1911 (Engineering News, Aug. 3, 1911, p. 156, Oct. 19, 1911, p. 475). These tests comprised the observations of corrosion on a series of metal plates placed in a railway tunnel where they would be subject to extreme effects of locomotive gases and in smoke jacks of a locomotive roundhouse. Complete chemical analyses and proportional loss of weight from corrosion of all the plates are given. As was to be expected, it was noted that the nonferrous metal plates, composed of copper and nickel principally, corroded least, and the iron and steel plates corroded most. It was also noted, however, that the special iron plates of composition supposed to be peculiarly safe against corrosion did not show up much better than the plain plates. As the tests were on only one plate of each kind, they were not very conclusive.

Allerton S. Cushman (Woolington, D. C.) called attention to the fact that tests of loss of weight per unit area were not regarded as of much value as corrosion, mainly because they do not reveal much regarding distribution of the corrosion or the extent of pitting. He also objected to the tests because they were on thin sections, with mill scale upon them and with no protective covering—all conditions not met in practice.

Magnetic Criterion of Mechanical Properties of Steel—C. W. Burrows (U. S. Bureau of Standards) showed a number of curves, illustrating the preliminary results of a series of tests he is now carrying out to show the relation between the magnetic and the mechanical properties of a 1% carbon steel. He hopes to be able to discover a fixed relation from which various mechanical properties can be predicted from magnetic behavior.

Ledebur Method of Oxygen Determination—W. R. Fleming (Newport, Ky.) in a paper opposed the use of the Ledebur method of determining the oxygen content in steel, mainly because it only determined the oxygen in combination with the iron. Dr. A. S. Cushman (Washington, D. C.) defended the method, which he introduced into this country, saying that it was only supposed to discover the oxygen in combination with iron.

Concrete Reinforcement from Re-Rolled Rails—Prof. W. K. Hatt (Purdue University) was retained during the past year by Subcommittee C of Committee A-1 to make an investigation to obtain data upon which to base a reasonable specification for re-rolled reinforcement bars, so called, that is, bars re-rolled from rails or similar material. Prof. Hatt made this investigation during the past year and reported upon it to the subcommittee. A condensed report of the investigation, which omitted the laboratory logs, tabulation sheets, etc., but which included all the salient facts of the tests, was presented to the present convention.

The tests were made on 2036 samples of reinforcing bars re-rolled from steel rails. Upon these samples 1719 tension tests and 1264 bend tests were made. The samples were selected from six mills without previous warning to the operators and the sampling was so arranged that it would have been impossible for anyone to have specially selected the rails sent to the furnaces from which the samples were taken. The bars were made in plain, special and hot-twisted shapes ½ in., ¾ in. and ⅝ in. in diamter and were tested in tension and in bending according to the regular specifications for ordinary reinforcing bars.

The investigation showed that the bars re-rolled from the head of an old rail were quite as good and as constant in quality as ordinarily rolled-steel reinforcing rods, but that the rods rolled from the web and the flange, while satisfactory for small rods, were not so constant in quality for the larger size rods. It was also found that the hot-twisted rods were not as good as the plain round or deformed rods. A further test was made upon special rails, testing the pieces from it before and after rolling. It was found from this that the process of re-rolling raised the mechanical quality of the material and brought nearer together the diverted material from the head of the flange.

The paper was accompanied by a number of diagrams and tables, so great a number in fact that it would be impossible to reproduce them in an abstract in this journal. The following table shows the proportion of these re-rolled bars that would pass the Society's standard specifications for concrete reinforcing rods adopted last year, which has been this year renamed "Standard Specifications for Billet-Steel Reinforcing Bars."

TABLE SHOWING ACCEPTANCES UNDER PRESENT SPECIFICATIONS OF RE-ROLLED BARS

		Percentage of Number of Bars Passing.				
Kind.	Size of Bar.	Bend.	Tensile Strength	Yield Point.	Elongation.	All Tests.
Twisted Bars.	All	92.1	94.1	95.9	95.0	83.4
	1 in. and below	92.0	94.8	94.6	95.0	84.0
	¾ in. and below	97.0	96.0	98.7	99.3	92.0
Other Bars.	All	97.2	99.0	....	98.2	95.1
	1 in. and below	98.0	99.0	98.2	98.3	95.7
	¾ in. and below	99.0	99.2	100.0	99.0	97.7

A new specification for re-rolled bars, as noted above under "Specifications," was drawn up on the basis of these tests.

There was no discussion of the tests.

Hardness and Wear of Steel—George L. Norris (American Vanadium Co.), in a paper entitled "Resistance of Steels to Wear in Relation to their Hardness and Tensile Properties," described some tests he had made on various hardness and wear-measurement mcahines. He found in general that there was no absolute proportion between hardness and wear.

Bearing Metals—P. D. Lynch (Westinghouse Electric & Mfg. Co., Pittsburgh, Penn.) presented a paper entitled "A Study of Bearing Metals and Methods of Testing." Hitherto, it has been found that most of the tests on babbitt metal, particularly the friction tests, were of small value as an indication of service quality. Mr.

Lynch's company has tried a number of imitation service tests, particularly those on motors running at excess speed and load, but had not been able to discover much of importance when it was decided after a somewhat satisfactory test by the Brinell ball method to institute a series of hammer tests.

In these tests metal was poured in small castings and turned to definite shape. It was then placed in the machine and subjected to the repeated hammering of a specially controlled lever hammer. From this test very good results as compared to service results were found. Somewhat later an improved hammer which acted on the drop principle was devised and that is now being used by the company in its tests of babbitted metal. Special attention has been paid in these tests to the temperature of pouring of the metal and it has been found that given a good quality of material in the beginning a fixed degree of temperature of pouring will generally guarantee a good babbitting metal. The author recommends that in manufacturing the metal it should be followed closely checked by chemical tests, Brinell tests, hammer tests, careful supervision and finally by the results in service.

Other Material

Tests of Primers and Top-Coat Paints—A series of test panels were exhibited by M. McNaughton (J. Dixon Co., Jersey City, N. J.), which showed very well the effect of different paints in different combinations of primers and top coating. The upper half of small steel plates were first coated with one paint as a primer, while the lower half was primed with another. The left half and the right half of the same plates were then top coated with the respective paints used as primers. This gave four different combinations which were observed through a long period exposed to atmosphere. The differences in the conditions of the surface were quite marked.

Testing of Chinese Wood Oil—E. W. Boughton (U. S. Department of Agriculture) in a paper with the above title, compared the various methods of testing the so called "tung" oil, more generally known as Chinese wood oil, which is being used considerably as a drying oil. While the paper presents a fair comparison of all different methods, and recommends certain methods as desirable, it does not come to any conclusion as to a proper specification for testing and is concluded as follows:

> As the question of the suitability of the oil for paint and varnish purposes is somewhat dependent upon the method of manufacture, individual methods of testing will remain as long as they are found to be of value.

It was recommended in the discussion that Chinese wood oil is now of such importance that at least a tentative specification for its testing should be written. It is hoped that Committee D-1 will present such a specification next year.

Tests for Road-Building Rocks—Logan W. Page (U. S. Office of Public Roads), had a paper which presented, mainly in tabular form, the relations discovered by his office between the various hardness, toughness and impact tests for road metal. Curves of comparison have been worked out, which, as was to be expected in a natural material, show a great variation in results. In general, the author stated, "the prime quality to be determined in road-building rock is that of toughness. The resistance to wear might also be obtained as very useful information, whereas the hardness test is of least value and might be omitted." He said, in discussion, that this applied, no matter what binder was used for the road.

Testing of Refractories—An important paper on this subject was read by A. V. Bleinniger (U. S. Bureau of Standards). It outlined the necessities of such tests and presented a brief résumé of the detail tests that are now available or in use by different laboratories and concluded with some specifications suggested by the Bureau of Standards. Prof. E. Orton, Jr. (Ohio State University) said that a committee on the subject should be appointed and his suggestion was referred to the Executive Committee for action.

Screen Scale for Sieves—G. A. Disbro (Cleveland, Ohio), in a paper entitled "Screen Scale Sieves Made to a Fixed Ratio," advocated the adoption of the so called Tyler Standard Screen Scale for the manufacture of sieves. He stated that the ordinary method of denominating sieves by the mesh is extremely inaccurate, inasmuch as it does not take care of the diameter of the wire or thread which makes up the screen. He illustrated this as follows:

> When we say 20 mesh it may be any screen with 20 openings to the lineal inch made anywhere from 0.0095- to 0.032-in. wire, with a chance of variation in the sieve opening of 0.0405 to 0.018 in., a difference of 0.0225 in., so that one person may have 0.018 in. in mind when referring to a 20-mesh screen and another an openig 225% larger, or 0.0405 in.

The Tyler Standard Screen Scale is a series of accurately measured openings that increase and decrease throughout the series in a fixed ratio. The scale has as its base an opening 0.0029 in. in diameter and the openings increase in the ratio of the square root of 2, or 1.414, a linear ratio of $\sqrt{2}$ and an area ratio of 2. It is a compromise between the Rittinger series and the Richards series of screen scales, which have been proposed at previous times.

Shipping Containers—Col. B. W. Dunn (Inspector Bureau of Explosives, American Railway Association) presented a resolution to the effect that the Society urge the Interstate Commerce Commission to extend to all classes of freight the protection against damage and loss through insecure shipping containers that the Commission is now endeavoring to extend to explosives and other dangerous articles, and that the Society offer the services of a committee to aid in this work.

Preliminary to this resolution, Col. Dunn offered a paper which showed that the necessary increase in freight handling efficiency has resulted in greater speed in the switching and coupling operations. This greater speed produces a very heavy shock on railroad trains, which shock is taken up largely in the steel underframes and the draft gear which have been provided for the latest freight cars. It, however, does not take up the shock in the freight itself, which is subjected now to much greater impact than it used to be. For this reason he consirs that some decided effort should be made to provide standard shipping containers for all freight that can be affected by this shock.

The resolution was heartily approved by several members on the floor and was adopted by the meeting to be referred to the Executive Committee for action.

Spherical Bearings—A new spherical bearing, which is in use in the Municipal Testing Laboratory of the City of St. Louis, was described by Mont Schuyler (St. Louis,

Mo.). This bearing is a diaphragm bearing to be substituted for the ordinary spherical bearings, which, according to Mr. Schuyler, have not proved entirely satisfactory. The diaphragm bearing comprises a rubber diaphragm on which the test piece rests, taking a bearing on a metal lower block, which is bored out directly under the test piece, so as to take a hydraulic sack. The pressure is then distributed through the diaphragm and the sack to the metal block. Mr. Schuyler's paper described the various spherical bearings which have been used and noted their defects.

TESTING MACHINES—E. L. Lasier (U. S. Bureau of Standards) had a paper which tabulated and described all of the very large-capacity testing machines in this country and in England.

THE STRAIN GAGE—A paper, by W. A. Slater and H. F. Moore (University of Illinois), entitled "The Use of the Strain Gage in the Testing of Materials," described in considerable detail the various gages, founded on the well known Berry gage, which are used to measure minute deformation of material under load. The authors have had a great deal of experience with these instruments, particularly in the testing of buildings under load, and the paper details the method of use, precautions in using and method of taking and reducing notes. Mr. Slater, who presented the paper, said that the successful use of the strain gage was largely dependent upon the exercise of care, first in the preparation of the gage holes, second in taking zero readings and third in systematic note reading and prompt reduction of notes.

Prof. Berry (University of Pennsylvania) explained some of the difficulties in the use of his gage and Profs. Talbot, Hatt and Marburg, whose laboratories have used the gage extensively, stated that in their opinion it was one of the greatest developments in the art of testing materials that has yet been discovered or put into use.

OTHER PAPERS

The following papers were also read, either by title or with limited discussion: "Result of Tests of Welded Boiler Tubes," by E. L. Lasier (U. S. Bureau of Standards); "Notes on the Property of Toughness in Metals," by A. F. Shore (Shore Instrument Co., N. Y.); "The Effect of Small Percentages of Vanadium on the Physical Properties of Steels," by George L. Norris (American Vanadium Co.); "The Chemical Tests of Heat-Treated Spring Steels," R. P. Devries (U. S. Bureau of Standards); "Metallographic Study of Lead-Tin-Antimony Alloys (Prof. Wm. Campbell, Columbia University); "The Strength of Cast-Zinc or Spelter," Gilbert Rigg and G. M. Williams; "Suggestions as to Standard Specifications to Promote Efficiency and Safety in Explosives Used in Blasting, C. P. Beistle (Chicago, Ill.). M. H. Wickhorst's paper, entitled "Rail Failures and their Causes," was reprinted in ENGINEERING NEWS, July 3, 1913, p. 23.

A $2,000,000 Terminal for the interurban electric railways of Dallas, Tex., is projected by Stone & Webster, of Boston, Mass. The terminal building will cover one city block (at Jackson, Wood and Browder Sts.) and rise nine stories above the basement. There will be 12 tracks running into the train shed which will extend 200 ft. along one street and 270 ft. along another, giving room for 35 interurban trains at once. It is designed for the operation of 500 trains per day and for 11,000 to 14,000 passengers. In the basement will be a heating plant and a substation supplying current for street and interurban cars and for the business section of the city.

Annual Convention of the American Institute of Electrical Engineers

The thirtieth annual convention of the American Institute of Electrical Engineers was held at the Hotel Ote-sa-ga in Cooperstown, N. Y., June 23 to 27, the society thus going back to its former practice of holding these annual meetings at well known summer resorts. The attendance (240) was not nearly as large as in the last two conventions (at Boston and Chicago) but it was representative of all phases of the profession.

The convention opened with a reception and dance, and there was the usual program of outdoor sports, including a ball game for all (in the rain); with card parties, concerts, etc., particularly for ladies.

An attractive function was the presentation of the Edison Medal "for meritorious work in electrical science" to William Stanley, inventor of the modern high-tension alternating-current power-distribution system, comprising an alternating-current generator and step-up and step-down transformer.

Another notable feature of the convention was the frequent, vigorous and protracted extra sessions of the delegates from local sections of the Institute discussing the conduct of the society in general. They were, in a sense, also safety-valve meetings for the registration of "kicks" from any member.

The technical program included 26 items, mostly separate papers. Mention of these, and of the discussion on them, is made below according to some general classifications which may be made, but not following the program, which was in the hands of special committees on (1) telephony and telegraphy; (2) education; (3) high-tension transmission; (4) industrial power; (5) power stations; (6) electric lighting and (7) electrophysics.

GENERAL ENGINEERING QUESTIONS

The president's address, by R. D. Mershon of New York, and the salutatory remarks of the president-elect, C. O. Mailloux of New York, made mention of the need and opportunity for broader consideration of engineering questions by this society and coöperation with others in advancing the interests of the entire engineering profession.

A paper by William McClellan, of New York, entitled "A Suggestion for the Engineering Profession," described a project to organize the "American Engineering Association" which would be made up of representatives appointed to represent the different engineering societies. This association would arrange an annual convention of engineers for the discussion of engineering in general or of the profession's status and related subjects, but not touching those scientific and technical subjects which come before meetings of the constituent organizations. The association would hold regular meetings for the discussion of the objects of the association and recommendations would be made to the member societies when needed. It would investigate and report on any subject which might be referred to it by a member of the society. It would be represented at congressional, legislative and other hearings, for the purpose of assisting in the proper decision of engineering questions affecting the public interest. It would make recommendations at any time to public officers as to engineering features of matters in which the profession might be interested.

The author put forward this novel proposition, as he evidently felt that the lack of proper recognition and influence of the engineering profession was due to its specialization and segregation into various sectional societies, in contra-distinction to the legal and medical professions.

The discussion was entirely commendatory of the objects and many believe that the means suggested was the most feasible. The view was advanced that existing societies, the American Society of Civil Engineers for instance, could and would act in somewhat such a capacity, but more speakers believed that the opportunity of that society to act for the general engineering profession has been lost.

Industrial Education

A group of papers was presented, having to do generally with the topic of industrial education, which a special committee has been studying for a couple of years.

Mr. F. C. Henderschott (New York) in a paper "The National Association of Corporation Schools" traced the organization and proposed efforts of this new society. It had sprung from the difficulty which the New York Edison Co. experienced in studying the work which had been done throughout the country in employees' educational courses, prior to establishing a school of its own. Canvass of the various industries showed that an association which would act as a sort of clearing house for such information on corporation schools would be well received. The association means to make corporation schools successful by disseminating information about pitfalls, etc. No attempt will be made to formulate courses, nor will it institute correspondence instructions. The first national convention of the association will be held Sept. 16 to 19, at Dayton, Ohio.

Prof. A. J. Rowland, of Philadelphia, in the paper, "Vocational Education in Philadelphia and Vicinity," set forth the work which was being done in evening class instruction in that locality. The author believed that local results showed that the difficulty in giving instructions to evening classes has been overestimated. His argument was that every one who has passed the regular school periods of life must do most of his studying in the evening, so that he must be used to it already. He believed that the short time necessary to cover a subject puts teacher and students on their mettle and gives great definiteness to the work, encourages attendance, etc.

One of the great drawbacks from which he found such vocational education to suffer, was lack of a comprehensive development. A man now starting on a course is apt to find, later on, that he has reached a point from which he can make no direct advancement, and a new start must be made in somewhat different direction. The author would grade the applicants for such courses into four groups: (1) men who have completed technical-high-school courses and who are ready, by preparation and ability, to enter on college-grade work; (2) younger men and boys with grammar-school training, who may be given work of high-school character; (3) older men who long have been away from study and who find mathematical operations and technical reasoning hard, who need training in principles and practise, but with arrangements so that they may gain knowledge in mathematical science to take up eventually work for men in group 1; (4) boys and young men, similar to group 3, but who must secure a certain amount of technical training at once, or who are not sure of their aptitude and taste for life work along technical lines.

Under the title "Vocational Training in the Far West," Prof. Robert Sibley (Berkeley, Calif.) showed that this work west of the Rocky Mountains is still in embryo, although notable cases of special work are to be found in Los Angeles, San Francisco and Visalia, Calif.

Prof. John Price Jackson (State College, Penn.) and J. W. L. Hale (Altoona, Penn.) described "The Pennsylvania Railroad Company Apprentice Schools." The purpose is to prepare young men for efficient work in the mechanic arts related to railroading. It was determined that the schooling should develop in the young man a strong ambition for improvement but should avoid developing discontent and unhappiness which come to those whose aspirations are beyond their capability or circumstances, as would happen if apprentices were led to believe that they would all obtain positions in which manual labor and skill were not required. Incidentally it was specified that the records should enable the company to lay hold of that small percentage of apprentices, who, by reason of exceptional brain power and ability, could be advanced beyond the ranks of skilled workmen to direct the labor of others.

The schools themselves are largely for mental training, but they are very carefully and closely related to shop instruction, under the shop foremen, who have placed upon them the responsibility for the training of the apprentices, and on whom falls the blame for failures of the latter. There are four schools at Altoona, Philadelphia, Wilmington and Harrisburg, with a total enrollment of about 320. It was believed by the officials that well established pedagogical methods could be employed in the most practical courses, and the Pennsylvania State College was called upon to formulate the methods to be pursued, and to take general supervision.

The apprentice courses are of four years' duration, and the school work covers three years of 42 weeks each. There are two 2-hour periods in each week, widely separated, to permit evening study between. The apprentice classes are divided into small groups, so that the men can be segregated according to capacity, and the instruction adjusted in accordance. The curriculum includes English, mathematics, physics, mechanics, mechanism, strength of materials, chemistry, mechanical drawing, machine design, steam engineering and shop management.

The discussion was protracted to great length, as discussions of educational subjects always are.

Corrosion of Iron

The paper entitled "Electrolytic Corrosion of Iron in Soils" by Burton McCollum and K. H. Logan, of Washington, D. C., contained a progress report of investigations which the U. S. Bureau of Standards is making into the electrolytic destruction of iron under various conditions.

The authors took samples of virgin soils and packed them in cans with iron rods which were made the anodes of proper electrical circuits. Among the effects found by a long series of experiments may be noted the following: (1) The amount of corrosion per ampere-hour is apt to be low in the case of fairly dry soil, while as the percentage of moisture approaches saturation the corrosion approaches that indicated by Faraday's law. (2) Temperature changes have no important effect on this "corrosion efficiency." (3) Depth of burial

of pipe has no direct effect, but the moisture content of soil carried by pipe, etc., will vary with depth so that indirect differences may be noticed. (4) The amount of oxygen present has no appreciable effect on efficiency of corrosion of iron immersed in liquid, but seems to have some for iron embedded in earth. (5) The amount of oxygen present has a marked effect on the results and products of corrosion; where corrosion is very rapid and the supply of oxygen small, there is a production of dark magnetic oxide, while if the rate of corrosion is low and the supply of oxygen abundant the lighter colored oxide will predominate. As the supply of oxygen around pipe buried in earth is limited, the character of the oxide formed gives some indication as to the rate of corrosion and indirectly as to the cause, if other local conditions are properly considered. (6) No material difference in efficiency of corrosion on different kinds of iron is shown; cast iron, "ingot iron," wrought iron and machine steel showed no great variations in efficiency of forced corrosion, though the pure "ingot iron" was a little higher. In natural corrosive action in soils, as expected, this last material was the lowest, but cast iron was the highest contrary to general belief. There was little pitting of cast iron however. (7) Trial of chemicals, found to inhibit either soft corrosion or forced (electrolytic) corrosion in liquids, showed no indication that material retardation was produced for irons embedded in soils. (8) The character of the pitting of iron embedded in soils is affected not only by homogeneity of the iron or soil, but also differs with different chemicals introduced. (10) Efficiency of corrosion was not found to depend on the voltage except as this affected current flow. (11) Tests on a large number of different kinds of soils from widely different sources with average moisture content and moderate current density indicate that efficiency of corrosion (agreement with Faraday's law) between 50 and 110% may usually be expected under practical conditions. (12) The resistance of the soils studied varied throughout a wide range with variations in the moisture content, the resistance of comparatively dry soil being several hundred times that of the soil saturated. Above saturation, any increase in moisture content has little effect on resistance and hence on current flow and corrosion.

The paper went on to show that the rate of damage in any practical instance, like the leakage from street-railway return circuits did not increase as fast as the leakage voltage increases, because of the tendency toward lower corrosion efficiency at higher current densities. This voltage changes with the load on the system, being greatest at peaks. A requirement which would limit the peak-voltage drop was held to be less logical than one which would limit the average voltage; and the reduction of average voltage is less expensive than the reduction of peak-voltage drop in railway-track circuits.

The discussion was generally commendatory of the scope and care with which the Bureau of Standards was carrying out such studies. It was stated that studies were being completed of pipe coatings which would probably show that the majority had only a limited usefulness. The studies with direct currents had been accompanied by similar ones with alternating current of very wide range in frequency which indicated that the secondary reactions following electrolytic dissolution of iron were comparatively slow so that the reversals of current largely produced a reversal of the destructive action. This is in accord with all published experiments.

Power Transmission and Distribution

Under the heading "Suggested Specifications for Testing High-Voltage Insulators" were three sets of specifications. The first by F. W. Peek, Jr., of Schenectady, N. Y., was drawn from the viewpoint of the testing engineer for the purchaser. The second, by J. A. Sandford, of East Liverpool, Ohio, was arranged from the standpoint of the manufacturer who felt that once the design was fixed the testing should be to insure uniformity of high-grade product. The third set was arranged by P. H. Thomas, of New York, from the other two sets; it separated tests of design from the routine mechanical and electrical tests at the manufacturer's plant.

In the discussion, a few lamented the reticence of manufacturers about their ceramic process and suggested that engineers should become familiar enough to dictate methods of manufacture. Others objected to such procedure as they believed that ceramics had not been reduced to an exact science; electrical porcelains were peculiarly variable and it was better to fix the requirements and let a manufacturer secure it if he could. One important new effect reported was that strains induced by pure mechanical loads reduced the resistance to electrical breakdown of porcelain insulators.

The paper by H. B. Dwight of Hamilton, Canada, entitled "Constant Voltage Transmission" was an argument for the use of unloaded synchronous motors ("rotary condensers") on transmission lines, but with their fields under the control of the line operator. The voltage drop due to apparent resistance and reaction under load can be compensated for by the voltage rise caused by the current drawn by such motors, the argued advantage being (1) a steady terminal voltage under all conditions of load, and (2) a doubling of the carrying capacity of the transmission line with a saving in line construction more than offset by the cost of additional machinery; (3) increasing the reliability of operation; (4) increasing the economical distance for transmission and making energy loss the limiting feature of transmission-line design instead of voltage drop under load.

The paper "The Industrial Use of Synchronous Motors by Central Stations" by John C. Parker, of Rochester, discussed much the same subject from a different point of view. He would apply such a scheme to lower-potential distribution, reducing the investment in rotary condensers by using synchronous motors driving commercial apparatus, presumably having some arrangement between the customer and the central-station company to make the use of such a motor attractive.

The discussion of this group brought out the limitations of these methods—when the energy drawn by the rotary condensers cost too much, when the skilled attendants were not to be found, etc.

Power Machinery

F. D. Newbury, of Pittsburgh, in his paper "The Behavior of Synchronous Motors in Starting" presented the results of oscillograph studies into the effect on field current and armature current of a different number of starting conditions for synchronous motors with induction-motor windings on the pole faces. He found several practical results. (1) With the field circuit closed on itself the effect on initial starting torque is negligible if the induction-motor grids in the pole faces are of good design. (2) With the field circuit left open during starting, dangerous voltages are induced in the field windings, so that for ordinary applications the motor should be started with the field circuit closed on itself. (3) Successively larger loads can be pulled into synchronism on starting if this synchronism is attained (a) on the starting voltage without excitation, (b) then on the starting voltage with field current and finally (c) thrown upon line voltage with full field current. (4) The minimum starting current is obtained for moderate loads by considerably over-exciting the motor fields before changing to final line voltage, but with large loads under-ex-

citing gives the minimum starting current. (5) A still further reduction in this starting current is secured by the use of reactance in changing from starting to line voltage and in this case the use of field current is delayed until the motor is very near synchronous speed.

The paper "Automatic Substations" by H. R. Summerhayes describes an automatic substation in Detroit in which was operated a synchronous converter controlled entirely from a distant station without any control wires other than the three load wires used to supply current. It has been found that the load on that part of the three-wire net work in one of the resident sections of Detroit had been increasing so rapidly that it was necessary to install more copper or renew substations to keep the service up to standard. Either alternative was too expensive for the revenue from the section. The engineers of the manufacturing company were required to furnish the equipment of such a station with the only connecting conductors being those carrying 4400-volt three-phase power from a substation to the district. The converter used was a six-phase, 12-pole, 500-kw., 300-volt machine connected to transformers on the alternating-current side. To start up the station, the operator at the distant substation throws one-third voltage on the line leading to the transformers, when the motor starts and reaches synchronism in 20 or 30 sec. Then a governor on this shaft closes a control circuit for the fields which are first thrown on with resistance in circuit. The distant operator sees the effects of these operations reflected in the rise and fall of his ammeter. Next he puts two-thirds normal voltage on the converter supply wires and later closes a running switch. Just after this a second automatic field contacter closes, cutting off the field resistance to give a strong field current. The direct-current voltage of the machine is low at this juncture, but is brought up by manipulation of a distant induction regulator. At the moment when the voltage reaches proper value a differential voltmeter carrying control-circuit contact operates the closing coils of two solenoid-operated circuit-breakers and throws the direct-current side upon the direct-current station busbars.

Such equipment is found to extend the economical limits of distribution, since the labor of operator and cost of heating form a large proportion of operating expense. The investment in feeder copper can be reduced by using smaller substations set closer together.

The discussion brought out some hesitancy in trusting the investment in large machines to automatic operation, though reliability of operation was not much feared by operating men who now rely on protection of automatic devices which act quicker than human attendants possibly can.

The paper "Converting Substations in Basements and Sub-Basements" by B. G. Jamieson describes typical arrangement of machinery in basements and sub-basements of large city office buildings. The difficulty of getting equipment into place and the troubles in procuring adequate cooling arrangements were taken up particularly.

Cost of Power

H. G. Stott and W. S. Gorsuch, of New York, presented a paper entitled, "Standardization of Method for Determining and Comparing Power Costs in Steam Plants." In it, they segregated power-station expenses in detail, under the heads (1) production and production-repair costs, (2) investment costs, and (3) general and miscellaneous administration costs, with explanations on the several items. Their scheme was proposed so as to have an accepted basis on which plant performances could be comparably studied—a task which central station engineers now resort to, to see if their commercial efficiencies are up to the average and where improvement is possible. To make the costs within one plant comparable from time to time, the authors introduced correction factors for (1) change in load factor (ratio percentage of average daily net energy output to hour's maximum output continued throughout the day), (2) change in average daily wages and (3) variation in coal supply. The power costs were found, by examination of a large number of records, to vary inversely proportional with the fourth root of the power factor; labor affected the cost according to the ratio of lower to higher average daily wage per man; variation in coals had an effect in proportion to the ratio of "figures of merit."

The paper was hailed as another classic contribution to central-station economics, a field in which Mr. Stott has done much valuable work. The "inverse-fourth-root" rule was particularly appreciated. Many frank criticisms were made of details of the accounting side of the scheme, such as distribution of officers' expenses, variations from standard accounts, the differences between the author's life-expectancy tables for equipment and data in common use. A few felt that many companies would object to giving up much of the investment data needed for such studies, while others held that utility concerns generally were coming to it, as they grew wiser under the protection of utility commission plans. Many speakers asked for the extension of the general method of heating and industrial power and even to manufacturing processes in general. By the author's desire, the paper was referred, through the Board of Directors, to the Standards Committee for study and promulgation as an approved method of cost analysis.

A Locomotive with Water-Tube Boiler and corrugated firebox or furnace flue of the marine type has been tried experimentally on the Prussian State Railways. The furnace is about 42 in. in diameter and 10 ft. long, with grate 8 ft. long. Beyond the bridge wall it opens into the bottom of the boiler barrel, which is filled with water tubes running from a header at the smokebox end and into the water chamber which surrounds the firebox (the end of which is closed by the tube plate). Horizontal baffles cause the products of combustion to pass first upward, then back toward the tube plate, and finally forward to a passage over the top of the header into through the ashpan and up into the rear end of the firebox. The engine is of the 0.8:0 class. It was built at the Orenstein & Koppel works, at Drewitz, and the boiler is known as the smokebox. The tubes are about 12 ft. long. Air passes the Strooman type.

Exports of Machinery from the United States had an enormous growth in the decade ending with 1912. In the year 1902, the total value of machinery exported from the United States to foreign countries was $64,826,000. In 1912, the machinery exports had increased to $176,700,000. Our largest customers for machinery are Europe and North America. Sixty-five million dollars worth of machinery was sent to Europe in 1912, almost double the amount exported to Europe in 1912. To North American countries outside the United States, $61,000,000 worth of machinery was sent. South America purchased $27,000,000 worth of machinery. The machines which bulk most largely in the export trade are agricultural implements, of which $33,000,000 worth were sent abroad in 1912, and automobiles, of which we exported $25,500,000 worth. Other important items in our foreign-machinery trade are engines, $19,000,000, metal-working machinery, $12,000,000, typewriters, $11,000,000, and sewing machines, $10,000,000.

EDITORIALS

The Underlying Cause of Accidents

In the course of the scientific study of accidents and their prevention which has had so great development during the past two or three years, perhaps the most prominent fact which has been developed is that the majority of accidents are not due, as is commonly supposed, to lack of safety appliances, but to the lack of safety habits on the part of those who are working in an industry.

During the past year an investigation has been made of every accident occurring on the Pennsylvania R.R., from the most serious train accident down to the cases of slight personal injury. Taking all these accidents together, it is stated that approximately 70% of them all could have been prevented if employees had exercised special caution. To put the same truth in other words, the cause of seven out of ten accidents which occur in railway service is that somebody blundered.

It follows, therefore, that the most effective work for accident prevention is the instruction and discipline of employees so that they will take greater care of themselves and of those for whose safety they are responsible. In furtherance of this end, the Pennsylvania R.R. has had printed 100,000 copies of a little 30-page booklet entitled "Safety Hints and Suggestions for the Prevention of Accidents," which will be distributed to officers and employees of the railroad company all over the system.

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Metal Rolled from Old Rails for Concrete Reinforcement

Readers of ENGINEERING NEWS will remember the extended and at times violent discussion that raged in these columns during the past year in regard to the merits and demerits of concrete reinforcement rolled from old rails. While most of the discussions presented only opinion—and very decided opinion at that—some few gave the result of experience both in test and in practice, and that experience generally was adverse to the re-rolled material.

It will be a matter of great interest to the many engineers who directly or indirectly took part in that discussion to read Prof. W. K. Hatt's report on the re-rolled rail as presented to the American Society for Testing Materials last week and abstracted elsewhere in this issue. Prof. Hatt, a testing engineer of long experience and accepted ability, gives the re-rolled rail a pretty good character as concrete reinforcement, not by direct statement, but by the results of his tests. Those results are much too long to present here, but we advise every engineer who is concerned with reinforced-concrete construction to procure a copy of the report and carefully to study the data there presented. He will find that the product of a number of re-rolling mills, carefully selected by Prof. Hatt's own force so as to preclude any influence of the producer on the choice of the test pieces, and also so as to insure a fair representation of the mill's run, showed in tests to be remarkably uniform and of acceptable, though quite high, tensile strength, particularly when rolled from the head of the rail, and not subjected to hot twisting. This is information of a kind which was needed but not available at the time of the discussion referred to above, and makes an important supplement to the views then presented.

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Good Work by State Conservation Commissions

When the arrangements were being made for the famous Conservation Congress held at the White House on invitation of President Roosevelt in June, 1907, those in charge of the preparations gave much thought to the question of how the Congress could achieve the greatest practical results. A committee made up of representatives of the national engineering societies gave especial study to this subject, and it was in accordance with the recommendation of that committee that the resolutions adopted by the Congress recommended legislation to create permanent conservation commissions in each of the States and also a Federal conservation commission.

In accordance with this recommendation, several of the Western States have established State conservation commissions which have done some very useful work. We have before us a recent report by the Oregon State Conservation Commission entitled "State versus National Control of Public Forests." As is well known, there has been an active movement by influential interests in various parts of the West to have some of the National forest reservations transferred from National to State control. On abstract principles, something might be said in favor of such a change, but as a matter of practical governmental experience it is well known that in most of the Western states, to say nothing of the Eastern, public property which is under state ownership is exceedingly apt to find itself transferred to private hands with very little in the way of resultant recompense to the state taxpayers. It is the interests which wished to use the national forests for private profit which have been most energetic in their endeavor to have the National forest reserves turned over to state control. Under these circumstances it is most valuable support for those who are endeavoring to protect the public interest to have on official State body, such as the Oregon Conservation Commission, speak out plainly in favor of a continuance of Federal control.

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Water Filtration at Cleveland, Ohio

A long period of highly turbid water at Cleveland, Ohio, following the late remarkable floods, and a reported increase in the number of typhoid cases, have given added strength to the persistent agitation for filtration which has been carried on in that city for several years past. Just before the recent continued bad condition of

the water came to our attention we stated (ENGINEERING NEWS, May 15, 1913) that the money which would be required for a filtration plant at Cleveland could apparently be spent with greater advantage for some other city purpose. Our opinion was founded in part upon an investigation and report made a year or so ago (see letter in ENGINEERING NEWS of Sept. 5, 1912) by a committee of the Cleveland Engineering Society. That committee (acting if we remember rightly, with some other learned societies of Cleveland) advised strongly against a $1,500,000 bond issue for a filter plant which had been previously authorized by the city council. As a result the project was given up. Agitation for it was continued but was persistently and successfully opposed by Mayor Newton D. Baker until a few weeks ago. Long continued muddy water and reports of the prevalence of typhoid appear to have conquered the mayor, at least to the extent of leading him to appoint a committee on filtration (see letter in our issue of May 22, 1913, p. 1078). The membership of the committee, we understand, made it a foregone conclusion that it would decide for filtration, and decide that way it did unanimously at its very first meeting. (The committee was a local one, with men of engineering experience in the minority.)

We had supposed that the logic of events, in the form of turbidity and typhoid, had convinced most of the doubters at Cleveland that filtration is desirable even if not necessary. It appears that this is not the case, for the Pure Water Committee of the Cleveland Engineering Society has made a report which questions the advisability of establishing a filtration plant. The committee, after promising a fuller statement of its reasons at a later date, summarizes its conclusions as follows, in a report drafted by Mr. Beardsley:

(1) It has been apparent to all users of water that an extraordinary condition has prevailed for some weeks, the supply having been unusually turbid and the turbidity having continued with very little abatement for an unusually long time. The cause of this was probably the abnormal and long continued rains of the latter part of March, the effect of these being still apparent in the present stage of Lake Erie (about 2 ft. above normal for this season) and in a turbidity of the water that extends over the entire lake, this latter condition never before having been observed.

(2) While your committee heartily approves the action of the Mayor in appointing a commission to investigate and report on present conditions, it very much regrets that this commission should have so far prejudged the case as to state publicly at its first meeting that filtration is now essential to a supply of wholesome water for Cleveland. The city is already committed, on excellent expert advice, to an extensive system of sewage treatment, and your committee is emphatically of the opinion that this should be carried to completion in advance of the construction of a filtration plant for the water-supply. Your committee is not ready to accept the apparent increase in typhoid cases reported during the past two months as an imperative reason for any change of policy, as it has learned by inquiry that physicians are by no means agreed as to the identity of many cases reported as typhoid.

(3) Your committee wishes to call particular attention to the report of Dr. Jackson, made about a year ago, in which he states that even with filtration, the use of chlorine would still have to be continued at certain seasons of the year, and this conclusion is supported by the fact that nearly all large cities now having filter plants, supplement this process with chlorination, thus disposing of the contention that our present chlorination plant is merely a temporary expedient.

(4) Filtration will undoubtedly make necessary an increase in rates and if it is found, after a competent investigation, that only an æsthetic purpose will be served, your committee believes that in justice to our manufacturing interests, now paying 40% of the Water Department revenue, the question of installing such a plant should be subject to a referendum.

F. C. Osborn, Chairman; C. F. Schulz, R. R. Abbott, Joe C. Beardsley.

In explanation of the reference to chlorination under (3) it may be stated that much of the recent agitation for filtration has been accompanied by strong language against the use of hypochlorite at Cleveland. Some of this language has been absurd but during cold water and perhaps during times of very bad water, when heavy doses of hypochlorite were required, the presence of chlorine in the water is said to have been evident to the senses.

Perhaps the most interesting question raised by the Cleveland situation is whether the recent turbidity is so abnormal and so unlikely to happen except at rare intervals as to make filtration unwarranted by the present turbidity alone. The same question as to providing public improvements of one kind or another to meet conditions of probably rare occurrence will arise again and again throughout the whole of the recently flooded district in Ohio and adjoining states. Obviously it will be physically and financially impossible to meet all these rare abnormal conditions by remedial or protective works. If wise counsels prevail, each local problem will be studied carefully in order to determine, first of all, its real significance, and secondly, its relative importance in comparison with other pressing needs of the community concerned.

Recent Developments in the Autoclave Test for Volume Constancy of Cement

The developments of the past year have proved correct our surmise of a year ago that the autoclave steam-pressure test for the constancy of volume of portland cement is the most serious attack upon the very generally accepted standard specifications for portland cement that has been proposed in many years. About 82,000,000 bbl. of portland cement were produced in the United States during 1912, and it is a fair estimate that 90% of this amount was delivered under the standard test adopted by the American Society for Testing Materials and the American Society of Civil Engineers. It is estimated also that up to the present there have been sold during 1913 between 800,000 and 1,000,000 bbl. of cement under the autoclave test. This, of course, is a very small percentage of the total 1913 production, but the use of the autoclave test is undoubtedly spreading and propaganda in its favor have been industriously circulated throughout the United States, to such an extent that its value is under the very serious consideration of the cement producers and of numerous large consumers who maintain their own laboratories for testing cement. When the great amount of production and in consequence the great amount of money involved in the manufacture of cement is considered, it is very evident that a most thorough study of any pronounced diversion from current-testing practice should be made before that diversion is incorporated into specifications for purchase.

It is now about thirteen months since H. J. Force, the chemist and engineer of tests of the Delaware, Lackawanna & Western R.R., presented in a paper in ENGINEERING NEWS the first publication of the autoclave test which he had devised and which had been adopted by his railroad for some of the largest concrete structures that have ever been built. From that time until the

meeting of the American Society for Testing Materials in Atlantic City the last week in June of this year there has been practically nothing new published upon the results obtained from the autoclave test. The discussion of Mr. Force's paper before the American Society for Testing Materials (reported in our issue of July 3) however, shows that a great number of independent investigators have been working upon this subject. In spite of these numerous and extensive studies, only inadaquately presented at the meeting, very little information of a positive character regarding the autoclave test is as yet available.

As we stated in these columns a year ago, the autoclave test is fundamentally a challenge from the engineer-user to the chemist-maker of cement. An engineer has before him two different cements. He makes these cements up in absolutely the same form of briquette and puts them into a closed vessel, there to subject them to a high temperature and pressure. At the end of a given time he opens the vessel, takes out the briquettes and finds one of them swollen in size and of considerably reduced strength while the other is harder and more compact even than it was when it was put in. He naturally concludes that the latter is the better material and demands of the prospective seller of the former material an explanation of the reasons for the difference in behavior of the two cements. Up to date the seller of the former material has not been able to give a satisfactory answer. The question then remains whether the engineer is justified in proceeding to the use of the test because he cannot be shown why it is not representative of the reliability of the cement under service conditions, or whether the burden of proof is on him to show that the autoclave test does detect unsound cement.

At the meeting of the American Society for Testing Materials the point was made that the engineer-user was not justified in making the assumption that the cement which passes the test successfully is a better cement for practical service than the one that does not pass the test. It was pointed out again and again that the chemistry of cement is one of the most involved now confronting the physical chemist, that there is today absolutely no sufficient explanation of the hydration of portland cement and that anyone who theorizes upon the effect of certain methods of manufacture or storage upon the behavior of cement is theorizing from an extremely unstable base. All accelerated tests on cement are supposed merely to show in a short time the relative general effect of long-time use. With the peculiar condition surrounding the hydration of cement, however, it might easily happen that an accelerated test would subject the material to such severe conditions that its behavior might be entirely different than would be its behavior under normal long-time use. Thus it was suggested that there is a possibility that the pressure and heat of the autoclave causes some such action on portland cement as does a somewhat similar physical condition upon the product known as a sand-lime brick. Other investigators reported that the results obtained in the autoclave test were extremely erratic; that two samples of one cement might pass, where two other samples taken the same day and from the same car might not pass. It has also been intimated that a cement not passing the autoclave test might be made to pass the test by the inclusion of some extraneous material which obviously would not be beneficial to the cement in a concrete.

These then are some of the arguments against the adoption of the autoclave test. They impose, we think, certain obligations upon the advocates of the test. When the test was devised it was assumed that, while it might throw out some good cement, it would invariably reject any bad cement—a condition which worries the producer more than the consumer. It is now charged that this cannot be relied upon, as the test gives erratic results and permits of a doctored cement passing the test. Were these charges made only by the cement manufacturers, who may reasonably be expected to oppose a more rigid requirement on their material, they would not be so impressive, but when independent testers, who are honestly looking into the virtues of the test, report that either it has not been proved successful or that it has proved unsuccessful we venture to suggest that adherents of the test are certainly under certain obligations to the profession at large.

The Lackawanna engineers themselves will admit that it is impossible to *prove* that the autoclave test is better than the boiling test; they occupy a decidedly advantageous position when they demand that they be shown why the autoclave produces such peculiar effects in certain cements, but in spite of all this they are also obligated to give to the profession all the information which they have which led them to the belief that the autoclave test is the best one. We do not consider that the tests presented by Mr. Force to the American Society for Testing Materials are sufficient, in view of the time that has passed since the first publication of the test, nor was the necessarily brief discussion fully expressive of the views of those others who have experimental data in hand. It is evident, therefore, that the time has come when all of the data on the autoclave test must be presented to an unprejudiced committee with full instructions and power to investigate it. If the test is a good one and will make for better cement, it is to be expected that the cement manufacturers will want to adopt it, although their present attitude in the investigation is not unbiased but is in the nature of an attack upon the test. If it is not a good test, as Prof. Carpenter well said at Atlantic City, engineers certainly do not want to impose a higher cost of manufacture upon the makers with a consequent higher cost of consumption, for a material which may be no better than that which we now receive.

We have said that Mr. Force's paper is incomplete. We have gone over the tables given there rather carefully and find some surprising results; results that are not indicated by the text of the paper. In the first place, the number of tests which he presents that run to six months are very few. Naturally no test on continuous strength is of any use unless it runs well beyond three months. Six months, in fact, is not enough; it may be many years before the difference between a so called autoclave cement and another cement can be detected by the strength-time curve. We have, however, gone over the figures and taken therefrom the figures of all the cements that passed the autoclave test and of those that did not pass the test. In most cases these cements have all been tested in the regular manner up to a six months' 1:3 tensile briquette test. The accompanying tables show the results of these

figures as taken by us from the tables presented by Mr. Force.

Table I shows in each figure given the average of all the tests for each mill on cement which passed the autoclave test and which had been tested (in most cases) up to six months. At the top of the column will be noted the requirements that the autoclave test imposes, according to the Lackawanna specifications published in ENGINEERING NEWS, Jan. 23, 1913, p. 185. These are that the cement shall have a 200-lb. tensile strength in air, a 500-lb. tensile strength after going through the autoclave test, an increase of 25% in the tensile strength and

Looking now at Table II it will be seen that the cements which did not pass the autoclave test for one reason or another had a seven days' strength of 334 lb., a twenty-eight days' strength of 387 lb., a three months' strength of 435 lb., and a six months' strength of 452 lb. These cements on the contrary have a characteristic slight increase between the three months' and the six months' strengths. The averages are further presented in diagrammatic form.

We do not present these figures to controvert the autoclave test. It is quite possible that the variations in testing are such that the dropping off in one and the slight

TABLE I. CEMENTS PASSING AUTOCLAVE TEST

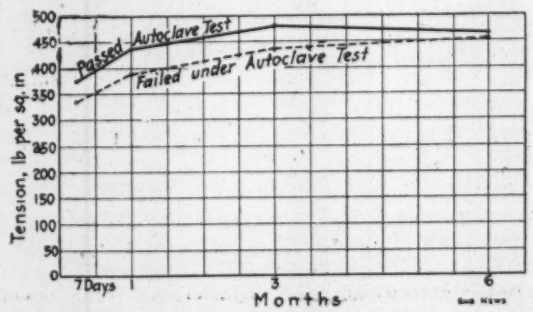
	No. of test averages of 3 each	No. of cars represented	Autoclave test: Tensile str. 24 hr. in air 16 per sq.in.	Autoclave test: Tensile str. 24 hr. 16 per sq.in.	Change in Tensile str. Inc.	Change in Tensile str. Dec.	Expansion %	Tensile str. 1 : 3 briq. open air 16 per sq.in. 7-day	28-day	3 mos.	6 mos.
Autoclave test	....	....	200	500	<25	....	0.50	250	375	...	...
Mill No. 1	11	33	435	667	55	....	0.12	373	413	462	463
Mill No. 2	13	64	410	631	57	....	0.20	383	457	492	473*
Mill No. 3	3	5	376	546	47	....	0.22	348	418	443	422†
Mill No. 4	4	14	378	548	49	....	0.30	365	438	490	447‡
Mill No. 5	2	5	329	533	63	....	0.60§	346	414	550	479
Weighted aver.	33	121	407	620	..	....	....	372	434	478	461

* Average of 3 which at 3 mos. average 478.
† One test which at 3 mos. average 448.
‡ Average of 3 which at 3 mos. average 473.
§ Failed in expansion test alone.

TABLE II. CEMENTS FAILING IN AUTOCLAVE

Mill No. 1	All cements passed autoclave test.										
Mill No. 2	2	14	363	461	27	..	0.95	339	412	451	450
Mill No. 3	1	3	392	387	..	1	0.41	326	350	432	482
Mill No. 4	9	40	387	212	..	44	1.94	367	423	459	457†
Mill No. 5	8	52	285	301	42‡	55	1.48	295	346	405	439
Weighted aver.	20	109	394	281	..	..	....	334	387	435	452

† Average of 5 which at 3 mos. aver. 461.
‡ 5 decreased and 4 increased.



AVERAGE STRENGTH-TIME CURVE FROM ABOVE TABLES

expansion not greater than 0.5% under the autoclave, and a tensile 1:3 briquette strength of 250 lb. at seven days and 375 lb. at twenty-eight days. All of the cements in Table I passed all of these requirements, with the one minor exception noted. Table II shows all the cements which for some reason or other failed under these requirements. The failure is for the most part in the 500-lb. per sq.in. requirement for tensile strength under the autoclave, although most of the cements also failed by having too great expansion. At the bottom of each table are given the figures for all the cements according to a weighted average; that is, each mill is weighted according to the number of test averages taken in that mill.

In Table I it will be seen that the cement which passed the autoclave test had a seven days' strength of 372 lb., a twenty-eight days' strength of 434 lb., a three months' strength of 478 lb., and a six months' strength of 461 lb. It will also be noted that this falling off between three months and six months is characteristic of all the mills, and if inspection of the tables in Mr. Force's paper be made, it will be seen that it is furthermore characteristic of practically every test.

rise in the other may be thereby accounted for. We do present them, however, to show that there apparently is small difference between the strengths under the ordinary tension test of the autoclave cement and of the cement which failed in the autoclave test, as presented by the deviser of the test himself, but that the cement failing in the test seems to have a better curve of increasing strength.

Increasing strength is not an indication of permanent soundness, of course; but if we could find a cement which would through five years, say, continually increase slightly or continue to maintain its original strength, we would be justified in assuming that to be a sound cement. The six months' indications are, therefore, altogether too short to allow of any judgment being made. They are sufficiently interesting, however, to indicate the necessity for a long-time investigation of the subject and to postpone judgment on the utility of the accelerated test. This investigation must be independent and thorough and not be affected by foreign decisions. It is notorious that the German standard tests, for instance, are controlled by the manufacturers and any reference to them is worse than useless.

Because of the fact that ENGINEERING NEWS published Mr. Force's paper a year ago and because also of the fact that certain interests have been using this article in an advertising campaign, it appears that a number of people have become convinced that ENGINEERING NEWS is advocating the autoclave test. That is not a fact. Neither is it a fact that ENGINEERING NEWS is attacking the autoclave test. Furthermore, it is not in sympathy with certain methods which have been used in attacking the test. Its position has been and is now one of complete impartiality with a desire to bring before the profession the fullest facts concerning what, if adopted, promises to be a very radical innovation. ENGINEERING NEWS trusts that the engineers of the Lackawanna R.R.

and Mr. Force will do their utmost to lay before the profession all the facts that they have in hand regarding the autoclave test. It also trusts that the committee to whom the test and the paper were referred at the Atlantic City meeting will not only proceed to an active consideration of the subject but will continue to preserve the unprejudiced and impartial attitude that is so necessary to the life and continuance of every technical society and especially of the American Society for Testing Materials.

LETTERS TO THE EDITOR

An Optimistic View of the Draftsman's Job

Sir—With regard to "A Draftman's Details" in the ENGINEERING NEWS of June 12, why should "A. T. N." be so pessimistic? I beg to submit the inclosed, which is somewhat more optimistic in tone, with due apologies to A. T. N.

E. A. VAN DEUSEN.

200 Fifth Ave., New York, June 16, 1913.

Ah what a life
The draftsman leads
In this glad world today;
He draws his plans,
He draws his breath,
He draws also his pay.
His working hours
Roll swiftly by
When he deserves a "raise";
His thoughtful brow,
Is thoughtful more
As increase meets his gaze.
He fills his pen,
Then draws a line,
And knows that things are fair,
And swears "I'll keep
This good old job
And work it on the square.
I'll hold my mind
Down to my task,
The blessed live-long day;
That boss of mine
Can never claim
I haven't earned my pay.
The boss expects
Me not to know
All things from A to Z,
But just to do
My utmost best,
And work efficiently.
Creative task
So satisfies,
That life is not a bore;
I'll 'beat it' home,
And in the morn
Gladly come back for more."

Concerning the Guarantee of Estimates by Engineers

Sir—Your editorial on the guarantee of estimates by engineers is very well written, very interesting and on the purely ethical side should meet with the approbation of every engineer; and if only all engineers were both ethical and experienced, your position would be perfectly justified, but—

Although I was not the engineer to whom you referred as offering to guarantee my estimate under bond, I have been forced to do this very thing in several cases; and I shall attempt to show you why I feel that it is necessary by citing one out of a score of instances to which I can refer.

A certain city had a bridge to build a few years since and their engineer asked me to make some preliminary sketches, which I did. The matter was in charge of the Park Board and I found them very friendly and favorable to me as matters progressed until very suddenly I received a letter from their engineer advising that the Mayor of that city had requested that they obtain competitive plans.

Four engineers submitted plans and I was the last to be heard by the Board. I learned that the highest estimate given by any engineer was $22,500 and as that was exactly the amount which the Board had to use, it was somewhat natural that the estimates should be in that neighborhood. I told the Board that I was willing to guarantee my estimate at $21,000, to include all cost of construction and engineering fees and they said that the other three engineers were willing to guarantee theirs. I asked how they would make good on their guarantees and my Yankee Board came back with the customary question as to how I proposed to assure them that my guarantee would hold water. I replied by a Surety Company bond up to $10,000.

To make a long story short, the engineering was awarded to a firm of whom one member was a brother to the Mayor and as I cannot be brother to all the mayors, much as I should like to be, I lost the job. Also, the lowest bid received on the plans was in the neighborhood of $29,000. Of the other two plans, neither could have been built with profit under $25,000.

I have had nearly 300 bridges erected under my own supervision and I have the detailed costs of nearly all of those bridges; so when I desire to make an estimate on a proposed bridge I use those figures to make an estimate which is just about right for an experienced contractor to do the work with a reasonable profit; and I stand ready to guarantee, if necessary, that it can be built within those figures. The average competing engineer has either never designed a concrete bridge or but a very few at the best and some of the estimates are either so high or so low as to be laughable.

It makes no difference whether the engineer be designing bridges, buildings or what you will, if he has had the experience which enables him to make a safe and sure estimate of cost, the only protection which he has against the inexperienced competitor who swears he can accomplish the work for a smaller sum is the guaranteed estimate.

Speaking of ethics, here is an instance which happened recently. A certain town voted to build a concrete bridge and two engineers submitted preliminary sketches of

which the cost was estimated on one at $28,000 and on the other at $35,000. The Board preferred the latter plan but, to avoid criticism, took both plans to a well known consulting engineer to ask him which, in his estimation, would be the better for them to use. He persuaded them that he could make them a plan which would be better than either!

D. M. W.

June 11, 1913.

More Concerning the Proposed Railway Inspection Organization

Sir—The communication from Mr. P. E. Stevens, in your issue of June 5, under the caption: "Joint Railway Organization for the Inspection of Structural Steel and Steel Rails," is peculiarly gratifying to the writer because it shows that the idea has advocates in the unexpected quarters of the inspection bureaus. There are a number of railway engineers and some bureau men who believe something of this kind will have to be done sooner or later, but are not yet ready to indorse it for various reasons. When they can be induced to come out and aid in shaping a plan for a better inspection, the movement may take on a really business-like aspect.

Mr. Stevens "takes issue with the writer on several points" but these apparent differences can be practically eliminated without materially changing the original suggestion. The writer does not believe that a "trust or combination of inspection bureaus would show better results" unless "a far sighted and broad management" could be assured. In fact, this suggestion was only advanced on account of the reluctance of railway men at this time to seriously consider the other suggestion of a mutual or coöperative inspection organization.

Mr. Stevens says that the practical man, working under an experienced engineer, makes a far better inspector than the technical man. But that is precisely the basis of the organization suggested in the minority report, only in the latter the practical men were classed as checkers and the "experienced engineer" as the "resident inspecting engineer."

One of the chief troubles with the present system is that the "experienced engineer" spends so little time on the job, or rather, is spread out too thin over too many jobs, with the result that the "practical man" has the advantage of consulting with him for only a few minutes in a week or perhaps in months. A bureau inspector told the writer that he once had a very difficult situation at a shop about 40 miles from the main office and telephoned and wrote for one of the firm to come out to advise him. He never saw either member of the firm, in response to his request. The plan suggested in the minority report provides for "a resident inspecting engineer, thoroughly familiar with all the details of structural steel and its fabrication" to be at the shop all the time. It also shows how the concentration of a large tonnage for inspection by one organization makes this possible at a reasonable cost.

The reference to rail inspection in the minority report was intentionally guarded, because the writer has not been practically engaged in that line; but he is disposed to support Mr. Stevens' suggestion for a wider field for the proposed "Railway Inspection Organization."

The question of originality had not occurred to the writer, but he is glad to acknowledge the prior work of Mr. Morgan T. Jones, although he was not previously aware of it. Possibly the earliest suggestion along similar lines was made in a conversation by the district manager of one of the largest inspection bureaus, in 1905 or 1906. This proposition included a full guarantee or indemnity insurance, and would have required a capital of from $500,000 to $1,000,000. Some of its features were attractive at first sight but it soon became apparent that it lacked elements to attract the necessary capital.

The writer wishes to thank Mr. Stevens for his contribution which has cleared up and improved some points and added new ones.

A. W. Buel.

New York City, N. Y., June 12, 1913.

NOTES AND QUERIES

The water-impounding system of the Southern California Mountain Water Co., a portion of which was described in our issue of June 12, was transferred to the city of San Diego on Feb. 1, 1913, a fact which we did not know when the article was prepared. We are informed by H. A. Whitney, hydraulic engineer of the Department of Water of San Diego, that the city now owns its entire "water system from mountain to meter." Nothing definite has yet been decided as to the construction of the proposed Barrett Dam, which has been under consideration for a number of years past by the company named and which is essential to the completion of the water impounding scheme as projected by that company.

Among the numerous suggestions of schemes for flood prevention offered by amateurs, of which the newspaper press has been full during the past three months, one of the most unique is the proposal of a Mr. Delong, a photographer, of Pittsburgh, Penn., to stock the streams with beaver and let them build the water-storage dams! The "Pittsburgh Post," of June 10, quoted Mr. DeLong as follows:

For every pair of beavers placed in the streams today $10,000 worth of property will be saved in the coming 10 years.

If you have never seen a beaver dam, you have no conception of its strength and bigness. Let me tell you that when dam building first began in America the best hydraulic engineers in the country went to inspect beaver dams and modeled stone and wooden dams after them.

The beavers fall timber across a stream and build dams on such foundations. As soon as the dam is complete, the water is checked and reservoirs are formed, sometimes an acre in area. Now what better reservoirs can the engineers who are discussing them build in Pennsylvania?

Beavers will soon become so plentiful that the state can either have a game season, or can sell off the excess each year. The fur is valuable and the business of raising beavers would be profitable.

All of which is evidence of the extent to which the work done by the engineer is understood and appreciated at the present day!

A Huge Steel Ingot, said to be the largest ever cast is illustrated in "The Engineer," of London, of June 6. The ingot had a total weight of 150 tons, was 24 ft. 6 in. long and of octagonal section with a thickness of 7 ft. 6 in. over the diagonally opposite corners. The ingot was cast at the Grimesthorpe works of Cammel Laird & Co., Ltd., of Sheffield, and was intended for some special naval construction for the British Admiralty.

A Duck Pond on a Small Stream tributary to a portion of the Brooklyn section of the New York water-supply system has been held to be a nuisance by the New York State Court of Appeals. The action in the case was brought by New York City against Benjamin Blum, of Rockville Centre (L. I.). The defendant owned several duck ponds on a stream tributary to the Brooklyn water-supply, and in these ponds he at times kept as many as 200 ducks. The city alleged that the ducks polluted the water-supply and sought an injunction to prevent the defendant from keeping the ducks unless the city was allowed to clean the ponds, place gravel on the slopes and construct a filter at the outlet of the pond, all at the expense of the city. It appears that the lower court granted a decision in favor of the city, and this decision has been upheld by the higher court.

Emergency Bridge Reconstruction: Baltimore & Ohio R.R.*

One of the largest and most important railway bridges destroyed by the March floods in the Ohio River Valley was the structure spanning the Big Miami River at Lawrenceburg, Ind., on the main line of the Baltimore & Ohio Southwestern R.R. The bridge was about 800 ft. above the mouth of the river, where it joins the Ohio. The bridge consisted of three 207-ft. truss spans on masonry piers and abutments, spanning the main channel on the east end, while the west approach consisted of 600 ft. of pile trestle 25 to 40 ft. high. The truss spans were about 55 ft. above low water.

The rapid rise of the Big Miami River on the morning of Mar. 25 carried out a large portion of the trestle approach at the west end, and about 2 p.m. the west pier collapsed, carrying the two west truss spans with it. The water at this time was 10 ft. below rail level. By midnight the current was estimated to be 18 m.p.h. The Ohio and Miami rivers continued rising until the crest of the flood had reached a stage of 69.8 ft. on Apr. 1. The water at that time was 2 ft. above the top of the rail at the bridge site.

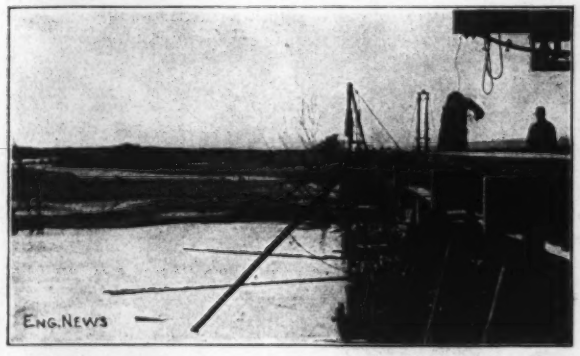


FIG. 1. DRIVING FOUNDATION PILING

FIG. 2. PLACING FRAME BENTS AND STRINGERS

Plans for temporary construction were begun at once. From the river crossing east to Cincinnati the roadbed was not damaged materially, but for a mile west from the crossing the embankment was badly washed and track moved from 100 to 200 ft. out of line. On account of the continued high stage in the Ohio and Miami rivers, little could be done on the repair work beyond perfecting an organization and moving material as close as possible to the bridge.

Owing to the inability to reach the west end of the bridge, it was decided to take the following equipment by steamer from Cincinnati: one 50-ft. land pile driver, two 50-ft. pile drivers mounted on sand scows 24x100 ft. and 24x50 ft., one extra 50-ft. pile driver and boat 24x100 ft., one small barge of coal, one extra 25-hp. boiler and engine, and the necessary tools and tackle. But on account of the continued high stage of the Ohio, it was impossible to load any of this plant until Apr. 5 and 6. The outfit arrived at the bridge at noon Apr. 7, and at 5 p.m. the pile-driving machinery was in operation. Each driver was double-crewed, and the work was carried on continuously in 12-hr. shifts.

Foundation piles (70 ft. long) were driven and capped, and 34-ft. framed bents placed upon them. hTe total length of bridge rebuilt was 800 ft. The total height of rail above river bed was 71 ft., the river having scoured on an average of 20 ft. below the normal level of its bed. Divers were employed to examine the river bottom and see that the piles were properly driven. Fig. 1 shows two floating pile drivers at work on the foundation piling (the one at the left setting a pile into place in the leads), while at the right the deck and track are being placed on the frame bents. Fig. 2 shows a track pile driver working as a crane in setting the frame bents on the caps of the foundation piling and placing the stringers for the deck of the trestle.

All material used in the temporary structure was unloaded at the east end of the bridge by a locomotive crane and one track pile driver, and towed to position by two 10-hp. motor boats. Work was seriously delayed by continuous rains and the varying stages of water in the Miami River, rendering it extremely difficult to carry on the work. The cutoff point for the piles was 2 ft. under water at various times. A 50-ft. deck girder was placed over the position of the old pier to permit of its reconstruction. The temporary structure was opened for traffic at noon, Apr. 27. No serious accidents occurred and there were no serious delays on account of breakdown of machinery.

The force in charge of the rebuilding of the bridge consisted of A. H. Griffith, Assistant Engineer, who was in general charge of the work; S. C. Tanner, Master Carpenter; J. O. Potts, Inspector of Maintenance on the day shift; H. R. Bricker, Inspector of Maintenance on the night shift. The force included 6 foremen, 36 men in pile-driver crews, 40 helpers and laborers, 50 bridge carpenters, one timekeeper and one material man. Comfortable sleeping quarters and an excellent dining room were provided for the force, and a good supply of food aided materially in keeping the men in good physical condition.

*From information furnished (at our request) by the Baltimore & Ohio R.R., through J. Hampton Baumgartner, Publicity Representative. The temporary reconstruction of the B. & O. R.R. bridge over the Muskingum River at Zanesville, Ohio, was described in our issue of May 29.—Editor.

A New Water Purification Scheme—The recent outbreak of bichloride of mercury poisonings has seriously impressed the Richmond, Va., correspondents of several New York newspapers. In the issues of June 24 there appeared dispatches which contained the following statement:

Dr. E. C. Levy, Chief Health Officer of Richmond, recently asserted that the typhoid epidemic was caused by the city water. He recommended that a bichloride plant be installed to purify the water and prevent the spread of the malady.

Needless to say, this is a libel on Dr. Levy's well known prophylactic activities.

Explosion of Grain Elevator in Buffalo, N. Y.

On Tuesday, June 24, 1913, at 3:52 p.m., the plant of the Husted Milling Co. at Elk St. and the New York, Chicago & St. Louis R.R., Buffalo, N. Y., was wrecked by an explosion, presumably of grain dust, and the consequent fire destroyed considerable property which was not blown up in the primary explosion. The exact number of men at work at the time it not known, but it is supposed to be about 170. On July 6, the dead numbered 29 and the seriously injured ran up into the scores.

The plant occupies an area of about 500 ft. long north and south and 170 ft. wide east and west and comprises an elevator with adjacent steel storage bins and somewhat more remote rectangular concrete storage bins and reinforced-concrete circular grain bins. At the rear and on the side were a number of small brick and corrugated-iron warehouses with the usual boiler and engine room and some few timber structures. The plant was partially burned some five years ago, but had been rebuilt.

What is known as Elevator A, midway between Elk and Prenatt Sts., was built about 20 years ago and was of the then prevailing construction; that is, bins built of 2-in. plank laid flat and spiked. The elevator had a capacity of 200,000 bu. Adjoining this wooden elevator on the east were a series of steel tanks. The original explosion probably took place in the elevator and the fire spread to the adjoining structures. It is not known just what structures were wrecked by explosion and which by fire, but the elevator is a total loss, as are also the steel tanks.

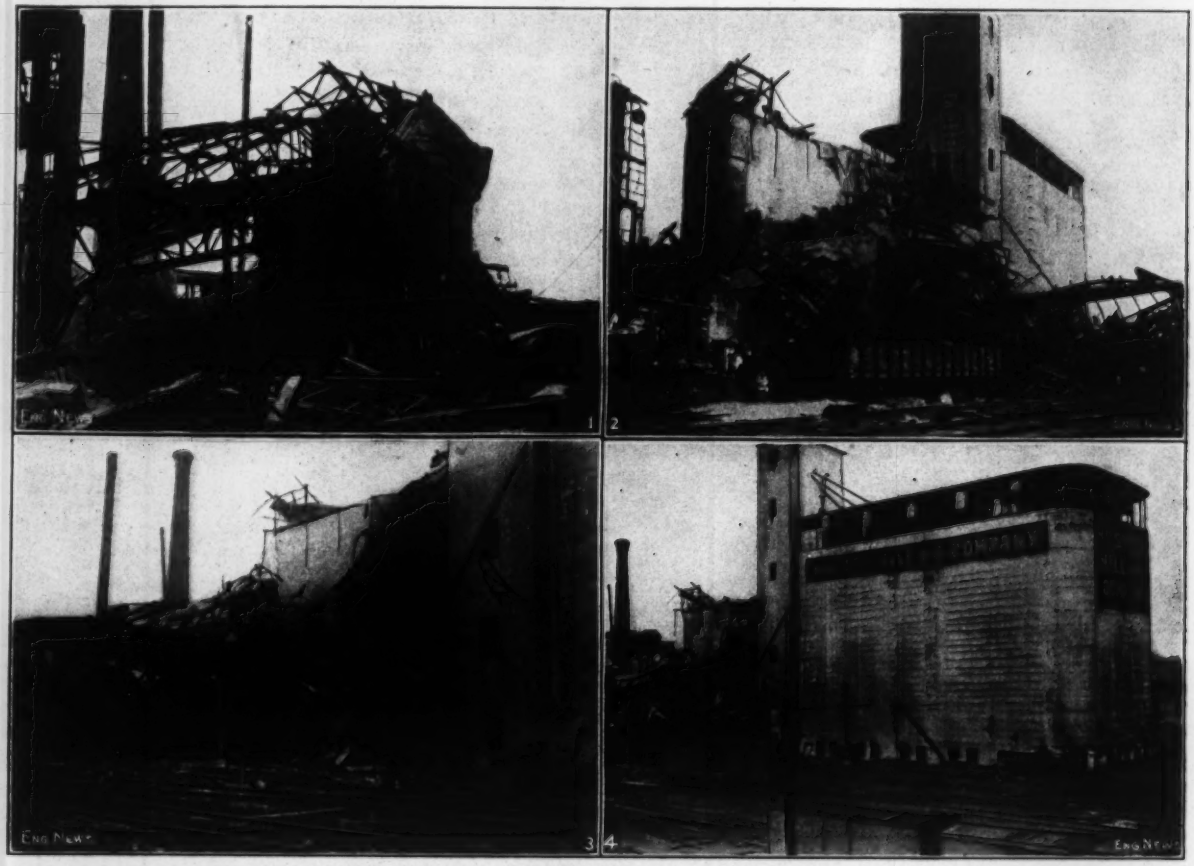


Fig. 1. Ruins of Elevator
Fig. 3. Wreckage in Plant

Fig. 2. Ruins of Elevator, with Reinforced-Concrete Tanks in Rear
Fig. 4. The Undamaged Reinforced-Concrete Tanks

Figs. 1-4. Views of the Wrecked Plant of the Husted Milling Co., Destroyed by Dust Explosion and Fire, June 24

Adjoining the tanks was a loading slip built of structural steel, which was destroyed by the falling débris from the wooden elevator, bins and steel tanks. To the north of the elevator is a battery of 18 reinforced-concrete grain bins built only a few years ago, and to the east of the elevator are some rectangular plan concrete bins also built some few years ago. Neither of these structures was injured except by falling material. The engine and boiler buildings were not harmed, except so far as they may have been injured by the falling débris.

Débris from the explosion was scattered all about the vicinity of the plant. The near-by railroad yards were heavily littered with small pieces of concrete. Lengths

sheet iron that were use as the outer covering of the wooden structures of the plant lined one side of the track. Other pieces were found in Elk and Smith Sts. near-by. A large sheet-metal ventilator about 8 ft. in diameter was also found in Smith St. A mass of the building fell over on the railroad tracks to the east and several strings of cars, some loaded with grain and others containing other commodities, were covered with the wreckage.

The business of the company was the transfer and grading of grain; that is of its receipts and storage in the various elevator bins and grading it before transshipment. Another branch was the manufacture of various mill products of corn and oats, such as cornmeal, cattle and chicken food, etc. No wheat flour was manufactured by the company.

It is not known as yet what was the cause of the explosion, though it is believed to have been a dust explosion. Numerous investigations, both official and private, are being held into the nature of the accident, but as yet none of them have been completed nor has any official or authentic explanation been given out.

The accompanying views show the condition of the plant after the fire. Fig. 1 is looking toward the smokestack of the power plant and shows the wreckage of the framework of the elevator. Fig. 2 is looking directly into the elevator with the concrete grain tanks to the right. Fig. 3 is looking also toward the power plant and showing the mass of wreckage on the ground, and Fig. 4 is a view of the undamaged reinforced-concrete circular tanks.

Frederic Danforth*

Frederic Danforth, M. Am. Soc. C. E., died at his summer home at Squirrel Island, Maine, June 6, as noted in our obituary columns of June 26. He was the son of Judge Charles, and Julia S. (Dinsmore) Danforth and was born Feb. 8, 1848. He graduated from Dartmouth College (Thayer School of Civil Engineering) in 1870 and was engaged in engineering work all his life, making his home and headquarters in Gardiner, Maine.

After graduation he was employed on the construction of the European & North American Ry. (now a part of the Maine Central R.R.), and later on the Portland & Ogdensburg R.R. (now the Mountain Division of the Maine Central). In 1883 Mr. Danforth was for a time employed on the construction of the Shore Line R.R., from Bangor to Mt. Desert Ferry (now also a part of the Maine Central lines).

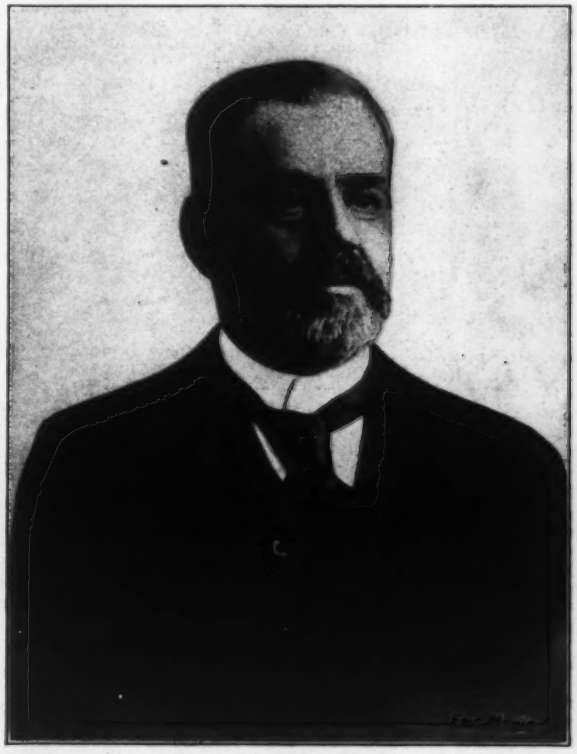
The following year he was made Chief Engineer of the Franklin & Megantic R.R. During the years 1885 and 1886 very little railroad work was done in Maine, and Mr. Danforth was employed in general practice. In 1887 he was engaged in water-works construction.

In 1888, however, he returned to railway work as Chief Engineer of the surveys for the Northern Maine R.R., a projected line to the Aroostook, which was never built. In 1889, in addition to this work he was made Chief Engineer of the Kennebec Central R.R., a narrow-gage line built for the accommodation of the traffic to the Soldiers' Home at Togus.

Late in the season of 1890 Mr. Danforth suffered an injury to his leg—the breaking of a muscle—which laid him off from active work for several months, but in the late summer or early fall of 1891 he was appointed Chief Engineer of the Portland & Rumford Falls Ry., the construction of which was about to start. This work, with the location and construction of the line from Mechanics Falls to a connection with the Maine Central R.R. near Auburn, occupied the years 1892 and 1893, and he had charge of improvements on the road for some years after.

In 1894 he was appointed engineer member of the State Railroad Commission and reappointed in 1897. He brought to this work a great fund of sound sense and great practical knowledge. He was a fine locating engineer, and had also made a special study of bridge work.

Mr. Danforth was a member of the city government of Gardiner for several years; he was Mayor for two years, and was for a long time a trustee of the Gardiner Water District. At the time of his death he was a director of the Gardiner National Bank.



FREDERIC DANFORTH

Mr. Danforth was married in 1880 to Miss Caroline Stevens, who with four children, survives him. The oldest son, Geo. C. Danforth, is now Assistant Engineer with the State Water Storage Commission, and the younger, Richard S. Danforth, is engaged in engineering work with a hydro-electric power development at Hood River, Oregon.

Mr. Danforth was a man of quiet tastes—a lover of home and family rather than of other society. He was everywhere respected for his character and ability. Always ready with advice when called upon, he will be greatly missed by all who knew him.

*Contributed by O. H. Tripp, M. Am. Soc. C. E., Rockland, Maine.

A Raft Ferry Sank in the Kiskiminetas River, near Leechburg, Kan., on June 28. There were about 60 men on board at the time. Five bodies have been recovered.

In a Butting Collision of a freight train and a work train, on the Chicago, Milwaukee & St. Paul R.R., near Clinton, Iowa, June 22, seven men were killed.

Municipal Ownership of the street railway and the electric-lighting systems of Toronto, Ont., has been under consideration for some time past. The two systems have been offered to the city for $29,000,000, of which $21,500,000 would be for that part of the Toronto Street Ry. within the city limits.

Educational Trips by Engineers in a City Department—The Engineering Division of the Bureau of Buildings, Borough of Manhattan, New York City, has adopted a practice—which might well be followed in other cities—of making inspection trips to bring the engineering staff in closer touch with the processes of manufacture and the properties of the building materials with which they, as building inspectors, have to deal. Two such trips have been made during the present season, one to the Vulcanite and Alpha portland cement plants near Easton, Penn., and the other to the terra cotta works of the National Fireproofing Co., at Raritan and Perth Amboy, N. J. The Superintendent of the Bureau, Rudolph P. Miller, has set aside occasional Saturdays throughout the year to be devoted to this phase of the Bureau's work.

A Municipal or District Improvement Plan for Ottawa, Ottawa, Ont., and vicinity may be prepared at the joint expense of Ottawa, Hull (Que.) and the Dominion Government. The plan would probably include local railway improvements, parks, main roadways and sewage disposal. The project has got far enough to warrant a letter on the subject from the Minister of Finance to the Board of Control of Ottawa.

A Railway Trestle Was Set on Fire, June 29, by a short-circuit, on an electric car of the Brooklyn Rapid Transit Co., which set fire to the two rear cars of the train. The flames were transmitted to the Jamaica Bay, L. I., trestle, used jointly in summer, by the Brooklyn Rapid Transit Co. and the Long Island R.R. The short-circuit was caused by a loose shoe on the car. The engineer of maintenance of way of the Long Island R.R. stated that the ties of the trestle were not creosoted.

Promotion of Efficiency in Civil Service is recognized in Chicago where the Cook County Civil Service Commission is advertising a civil-service examination for the position of Chief of the Efficiency Division at a salary of $3000 a year or more. It will be the duty of the appointee to study problems in the County service, the standardization of service and pay, the maintenance of individual efficiency record systems, and a study of methods for improving the county service.

The New Rapid Transit Lines now under contract in New York City have an aggregate cost of about $81,000,000, and cover about 27 m. of new construction, with a total trackage of about 100 m., as nearly all the new lines are of four-track construction. About 21 m. are of underground construction and 6 m. elevated. Fourteen different contractors are engaged on the work and the average labor force during the month of June was about 6400 men. The section nearest completion is that on Lexington Ave., from 106th to 118th St., being built by the Oscar Daniels Co., on which the work is now 68% completed.

Three 100,000,000-Gal. Submerged Centrifugal Pumps are to be installed at the Newark Bay pumping station (Newark, N. J.) or the Passaic Valley sewerage district. The pumps will be driven by direct-connected engines, supplied with steam from vertical internally fired boilers. The pumps must be able to deliver 100,000,000 gal. per hr. against a 37-ft. lift, or 50,000,000 gal. against a 20-ft. lift, and "at all rates between." Bids for these engines, pumps, boilers and other accessories were asked on July 1, 1913, by the Passaic Valley Sewerage Commissioners, Essex Bldg., Newark, N. J. William Brown is chief engineer, and John S. Gibson is clerk of the commission.

Railway Signal Towermen are held by the U. S. District Court for the Southern District of Texas, to come under the injunctions of federal statutes prohibiting an "employee, who by the use of telegraph or telephone, dispatches, reports, transmits, receives or delivers orders, pertaining to or affecting train movements" from remaining on duty more than nine hours in any 24-hr. period. The case is that of the United States versus the Houston Belt & Terminal Ry. Co. The decision of a lower court was reversed and it was held that an order affecting train movements may be given by the hand or a lantern for transmission and its disobedience can be as disastrous as in the case of a written order.

Spreading Rails, resulting from expansion due to the heat, caused the wreck of a Chesapeake & Ohio Ry. passenger train, near Fulton, Ind., on June 18. Two Pullman cars and a diner turned completely over, but no one was killed. The same cause, at Caseyville, Mo., on June 24, resulted in the derailment of a train on the Vandalia R.R. Press dispatches state that an eastbound train had passed over the same track shortly before the occurrenice of the latter accident.

A train, on the Louisville & Nashville R.R., on its way from Cincinnati to Atlanta, Ga., was wrecked, by spreading rails, at Lott, Tenn., June 29. The engineer and the fireman were killed. The locomotive plunged over an embankment, breaking the couplings and setting the air brakes, so that the cars remained on the roadbed.

Record Rainfall at Panama—Precipitation was general over the Isthmus during the week ending May 17, and was unusually heavy along the Atlantic coast. At Porto Bello on May 14-15, 10.65 in. of rain fell during a period of 24 consecutive hours. This 24-hr. record has been exceeded on the Isthmus once only during the period covered by the Commission records. This was at Porto Bello also—on Dec. 28-29, 1909—when 10.86 in. of rain fell in 24 hours. The 48-hr. rainfall at Porto Bello on May 15 and 16, amounted to 16.76 in., which exceeded any previous record on the Isthmus for a period of 48 consecutive hours.

Isthmian rainfall records in excess of 10 in. in 24 hours are, as follows: Gatun, 10.48 in., Dec. 2-3, 1906; Porto Bello, 10.86 in., Dec. 28-29, 1909; Porto Bello, 10.65 in., May 14-15, 1913. ["Canal Record," May 21, 1913.]

A Wooden Footbridge Leading to a Public Bath House Collapsed, June 30, at Lawrence, Mass., from the weight of about 40 boys, who were precipitated into the river. Eleven were drowned. The structure was a narrow wooden walk, spanning water 15 ft. deep, and leading to the municipal bath house on the Merrimac River, which has a swift current at this point. The boys were impatiently awaiting the bath-house keeper when the failure occurred.

The second floor of the rear piazza of a three-story tenement house at Brookline, Mass., collapsed on June 27. Fourteen children were on the piazza at the time of the accident. Three were badly injured.

These two accidents call to mind the conclusions of our editorial of June 19, that the design of such wooden structures is usually a rough approximation, since it is very difficult to estimate the maximum loads which such structures may be called upon to sustain.

Progress on the Hell Gate Bridge, New York City—Construction work on the New York Connecting R.R., which is to connect the Harlem River branch of the New York, New Haven & Hartford R.R., at 142d St., Borough of the Bronx, New York City, with the Sunnyside yards of the Pennsylvania R.R. at Long Island City, Queens Borough, has now been progressing for over a year. The whole distance is ten miles, and there will be four tracks. The crossing of the lowlands and water courses in the vicinity of Hell Gate, at the entrance of East River to Long Island Sound will be one of the longest bridges or more properly speaking, viaducts, in the world; it will have a total length of 15,840 ft. The Hell Gate bridge proper is to be a steel arch of 1000 ft. span, rising 300 ft. above the water. An illustration and brief description of the proposed bridge was published in our issue of May 30, 1907, p. 583. It will be the largest steel arch bridge in the world, as well as being remarkable for the heavy loads it will carry.

Work was begun at the Bronx and Long Island ends of the viaduct in July, 1912. On the Hell Gate towers for the arch bridge work was begun last September. The work thus far has consisted chiefly in building the concrete abutments and retaining walls in the Bronx and Queens Boroughs, and in constructing the foundations of the abutments for the great arch. This concrete work has now advanced so far, however, that within a few months the erection of the steel for the viaduct will begin.

The abutment towers, which are to carry the steel arch, will be of concrete, 250 ft. high. They will be 140x104 ft. at base and 100x75 ft. above the base. The foundation of the Long Island tower has just been completed. Here it was necessary to go down only 25 ft. to get bedrock, but it will be many months before even the foundation of the tower on the Ward's Island side is completed, for the bedrock is 150 ft. below the surface, and the work must be done by sinking caissons. At the present time caissons are being sunk for this tower in the same manner as they were sunk for the towers of the great city bridges farther down the East River. It will probably be a year or more before any steel work is begun on the Hell Gate arch.

At present half of the 32 concrete piers and abutments of the viaduct in the Bronx have been completed. They range in height from 30 to 50 ft. About 900 ft. of retaining wall for that portion of the viaduct which connects the road with the New Haven tracks at 142d St. has been completed. To fill between the retaining walls of this viaduct, which will average 35 ft. in height, spoil will be obtained from the New York subway excavation.

In Long Island City, seven piers and abutments and two concrete arches over streets have been finished, and 1000 ft. of retaining wall has been built. Work on the eastern viaduct, as the Long Island City part is called, will be completed, it is expected, within two years.

At present there are about 1000 men employed on the actual construction work of the bridge and viaducts. The entire work will require about 90,000 tons of steel and 450,000 cu.yd. of concrete, reinforced with about 5000 tons of steel rods. Gustav Lindenthal is Chief Engineer. The work will be completed within four years.

When this bridge is completed through trains will be run from Boston to Chicago, Cincinnati, New Orleans, Washington and Florida. President Mellen, of the New York, New Haven & Hartford R.R., has said that he intended running 40 trains a day over the bridge into the Pennsylvania R.R. station in Manhattan. This would mean a larger through service over the Hell Gate bridge than there is running today out of New England over the New Haven's main line alone.

PERSONALS

Mr J. T. King, Assistant General Superintendent of Transportation of the Atlantic Coast Line R.R., has been promoted to be General Superintendent of Transportation.

Mr. A. G. Armstrong, Division Foreman of the Atchison, Topeka & Santa Fé Ry., Coast Lines, at Los Angeles, Calif., has been promoted to be Master Mechanic at Needles, Calif.

Mr. F. R. Phillips, recently General Manager of the Sauer and Mack motor truck factories of the International Motor Co., has been appointed Assistant to the President at New York City.

Mr. William Bibby, formerly Roadmaster of the Grand Trunk Ry., at Allandale, Ont., has been appointed Assistant General Roadmaster of the Central Vermont Ry., at St. Albans, Vt.

Mr. A. S. Moore, Engineer of Maintenance-of-way of the Cleveland, Cincinnati, Chicago & St. Louis R.R., at Springfield, Ohio, has resigned to accept a position with the Union Fiber Co., Winona, Minn.

Mr. William D. Wiggins, Assoc. M. Am., Soc. C. E., recently Superintendent of the Vandalia R.R., at Decatur, Ill., has been appointed Valuation Engineer of the Pennsylvania R.R. Lines west of Pittsburgh.

Mr. H. J. Moore has been appointed Division Engineer of the Oklahoma division of the Atchison, Topeka & Santa Fé Ry., at Kansas City, Kan., succeeding Mr. F. L. Guy, transferred to the Eastern division at Emporia, Kan.

Mr. H. H. Althouse, formerly Chief Engineer of the Erie R.R., has opened an office at 172 Fulton St., New York City, as a consulting engineer, specializing in railway work, coal and ore handling plants, and the elimination of grade crossings.

Mr. Frank T. Hyndman, formerly Mechanical Superintendent of the New York, New Haven & Hartford R.R., has been appointed Superintendent of Motive Power and Cars of the Wheeling & Lake Erie R.R., with headquarters at Cleveland, Ohio.

Mr. R. Keith Compton, Chairman and Consulting Engineer of the Baltimore (Md.) Paving Commission, has been appointed Chief Engineer of the commission, relieving the City Engineer, Mr. H. K. McCay, of his duties in this connection.

Mr. Harry Braithwaite Abbott, former General Superintendent of the Canadian Pacific Ry., recently celebrated his 84th birthday at his home in Vancouver, B. C. He first visited Vancouver in 1885 on the completion of the Canadian Pacific Ry.

Mr. W. S. Burnett, formerly District Engineer of Construction of the Cleveland, Cincinnati, Chicago & St. Louis R.R., at Middletown, Ohio, has been promoted to be Engineer of Maintenance-of-way, at Springfield, Ohio, succeeding Mr. A. S. Moore resigned, as noted elsewhere.

Mr. R. K. Rochester, Division Engineer of the Vandalia R.R., at Terre Haute, Ind., has been promoted to be Superintendent of the Peoria division, with headquarters at Decatur, Ill., succeeding Mr. W. D. Wiggins, Assoc. M. Am. Soc. C. E., promoted as noted elsewhere.

Mr. H. C. Estep, Engineer of Construction of the Southern New England Ry., the abandoned Connecticut extension of the Grand Trunk Ry., has resigned and the position has been abolished. Mr. H. A. Phelps has been appointed Division Engineer at Providence, R. I., succeeding Mr. T. I. Ellis, resigned.

Mr. John F. Wallace, Past-President, Am. Soc. C. E., President of Westinghouse, Church, Kerr & Co., New York City, has been appointed Engineer of the Chicago City Council Committee on railway terminals, to make an expert investigation of the various proposed plans for the erection of the new terminals.

Mr. John Calder, M. Am. Soc. M. E., for several years Manager of the Remington Typewriter Works, at Illion, N. Y., and more recently Assistant to the President of the Cadillac Motor Car Co., Detroit, Mich., has been elected President of the International Motor Co., of New York City, succeeding Mr. C. P. Coleman, resigned.

Dr. W. F. M. Goss, Dean of the College of Engineering at the University of Illinois, has been appointed Chief Engineer of the Smoke Abatement and Railway Electrification Committee of the Chicago Association of Commerce, to succeed the late Horace G. Burt. He has received leave of absence from the University for one year to enable him to carry on this work, which is of immediate importance in view of the developments of the railway terminal problem at Chicago.

Mr. Collingwood B. Brown, Jr., Assoc. M. Am. Soc. C. E., formerly Principal Assistant Engineer of the Canadian Pacific Ry., at Montreal, Que., has been appointed Chief Engineer of the Canadian Government Rys., with headquarters at Moncton, N. B. Mr. Brown graduated from Cornell University in 1901. He has served in various engineering capacities on the Canadian Pacific Ry. from rodman, Resident Engineer and Assistant Division Engineer to Principal Assistant Engineer. Mr. Brown was born at Kingston, Ont., 36 years ago.

Mr. Richard C. Harrison, former private secretary to Mr. John Purroy Mitchell, recently President of the Board of Aldermen, New York City, and now Collector of the Port of New York, has been appointed Second Deputy Commissioner of Docks and Ferries, New York City, succeeding Mr. William J. Barney, Assoc. M. Am. Soc. C. E., resigned, as noted in our issue of last week. Mr. Harrison was formerly in the franchise department of the Public Service Commission, First District. The position of Deputy Commissioner of Docks and Ferries carries a salary of $5000 per annum.

Mr. George M. Brill, M. Am. Soc. M. E., has retired from the firm of Brill & Gardner, Engineers, 1134 Marquette Bldg., Chicago, Ill., and the partnership has been dissolved. Mr. Brill is at present in Germany with the visiting party of the American Society of Mechanical Engineers and will continue to spend some time in travel and study in Europe before returning to this country. The business of the former firm of Brill & Gardner will hereafter be conducted under the firm name of Gardner & Lindberg, the members of which have been associated with Mr. Brill for several years.

The members of the new Public Health Council, established by the recent New York State law, are as follows: Chairman, Dr. Herman M. Biggs, New York City; Dr. Simon Flexner, Director of Laboratories of the Rockefeller Institute for Medical Research, New York City; Mr. Henry N. Ogden, M. Am. Soc. C. E., Special Assistant Engineer, New York State Department of Health and Professor of sanitary engineering, Cornell University; Mrs. Elmer Blair, President of the Women's Club, of Albany, N. Y.; Mr. Henry Folks, Secretary of the State Charities Aid Association, and Dr. Edwin Clark, of Buffalo, N. Y.

Mr. Charles Hansel, M. Am. Soc. C. E., Consulting Engineer, of New York City, has been appointed Consulting Valuation Engineer of the Pennsylvania R.R., the Pennsylvania Co., and all the Pennsylvania R.R. affiliated lines, and will have the supervision of the work of making a valuation of these properties on behalf of the railway companies. The President's Committee of the Railroads, recently organized to look after the railway interests under the new valuation law, has appointed Mr. Hansel a member of the Committee of Engineers to confer with the Interstate Commerce Commission and its Board of Engineers in the preparation of all matters relative to the valuation of the railways.

Mr. W. L. Thompson, M. Am. Soc. C. E., Assistant Engineer, Isthmian Canal Commission, Corozal, Canal Zone, Panama, has

resigned to become Chief Engineer of the Mississippi State Levee Board, succeeding Mr W. J. Shackelford, M. Am. Soc. C. E., resigned. Mr. Thompson was formerly Assistant Engineer for the Levee Board and has had several years' experience with the Mississippi flood problem. He was born in Mississippi and graduated from the Mississippi Agricultural and Mechanical College in 1897. He began his engineering experience as a rodman with the Mississippi Levee Board and in four years rose to be Assistant Engineer in charge of location and construction. In 1905 he went to work on the Panama Canal as an instrumentman and chief-of-party on surveys and location.

Mr. F. Z. Nedden, of London, England, has been appointed Engineer in charge of the centrifugal pump department of the Goulds Manufacturing Co., Seneca Falls, N. Y. Mr. Nedden was educated at the University of Berlin in Germany. For seven years he was employed in the shops of the Berliner Maschinenbau A. G. vormals L. Schwartzkopff in Berlin and Wildau. From 1906 to 1908, Mr. Nedden was Assistant Professor at the Technical University at Aix-la-Chapelle. In 1908, after a trip through Europe to investigate the manufacture and application of high-lift turbine pumps he entered the machine and pump factory of Weise & Monski, Halle, Germany, where he developed a series of high-lift turbine pumps. In 1910 he was transferred to the firm's London headquarters, where he had charge of its English and Colonial business. Mr. Nedden is the author of several textbooks in German, some of which have been translated into English. He is a member of the Verein Deutsches Ingenieure and other technical and engineering societies.

Mr. L. D. Cornish, M. Am. Soc. C. E., for the past five years Designing Engineer, Isthmian Canal Commission, Culebra, C. Z., Panama, under Col. H. F. Hodges, Assistant Chief Engineer, has resigned. Mr. Cornish was born at Lee Center, N. Y., in 1877, and graduated from Syracuse University in 1902. After a few months' work with the New York Central & Hudson River R.R., he obtained a position in the United States Engineer Department at Pittsburgh, Penn., on the design and construction of movable dams on the Ohio River, where for three years he served under Col. William L. Sibert, now Division Engineer of the Atlantic Division of the Panama Canal. Mr. Cornish was early connected with the Panama Canal work; he was ordered to Washington, D. C., from his Ohio River work in the fall of 1905 to assist the International Board of Consulting Engineers appointed to decide on the type of canal to be built. The following February he was appointed to a position under the Isthmian Canal Commission, at Washington, and was assigned to the work of designing the spillways and protective features of the canal. In June, 1907, he was appointed Designing Engineer under Col. Sibert on the Isthmus, and a few months later was promoted to be head of the subdivision of the Chief Engineer's office in charge of general lock design, masonry, reinforced concrete and valves. This office he has held until the designs have been completed.

OBITUARY

Flavious Morse Crocker, Chief Engineer of the L. Schreiber & Sons Co. iron works, of Cincinnati, Ohio, died June 24. He was born in Haverhill, N. H., in 1865 and graduated in civil engineering from the University of Michigan in 1889. Following his graduation he was a structural designer in the employ of Jenney & Mundy, Architects, of Chicago, Ill., on work for buildings of the Worlds Fair of 1892. Later he was employed by Cincinnati architects and was Superintendent of Construction for the first high steel building erected in that city. He had been with L. Schreiber & Sons Co., for the past 19 years. Mr. Crocker was a member and Past-President of the Cincinati Engineers' Club.

A. O. Anderson, Assistant Engineer of the Engineering Experiment Station of the Iowa State College of Agriculture and Mechanic Arts, at Ames, Iowa, died May 16. Mr. Anderson was a graduate of Iowa State College in mining engineering in 1906. Besides his work as Engineer and Chemist of the Engineering Experiment Station he was at various times engaged in much outside work, including the design and supervision of construction of the sewer system and sewage disposal plant of Lake City. He was a member of the Western Society of Engineers, the American Society for Testing Materials, the National Association of Cement Users and the Iowa Cement Users Association. Mr. Anderson was joint author with Prof. A. Marston of several Bulletins of the Experiment Station, particularly on the subject of cement and clay pipe tests.

ENGINEERING SOCIETIES

COMING MEETINGS

OHIO ELECTRIC LIGHT ASSOCIATION.
July 15-18. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 17-19. Annual summer meeting at Buffalo, N. Y. Secy., E. A. Scott, 29 W. 39th St., New York City.

INTERNATIONAL GEOLOGICAL CONGRESS.
Aug. 7-14. Twelfth annual session at Toronto, Ont. General Secy., R. W. Brock, Director of Geological Survey of Canada, Ottawa, Ont.

THE TRAVELING ENGINEERS' ASSOCIATION.
Aug. 12-16. Annual convention at Chicago, Ill. Secy., W. O. Thompson, New York Central Car Shops, East Buffalo, N. Y.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.
Sept. 1-6. Annual convention at New York City. Secy., Jas. McFall, Roanoke, Va.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 10-12. Annual convention at Philadelphia, Penn. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 9-13. Annual meeting at Colorado Springs, Colo. Secy., S. M. Guma, 755 Boyleston St., Boston.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 9-12. Annual convention at Ottawa, Ont. Secy., A. P. Dane, Reading, Mass.

Society for the Promotion of Engineering Education—We supplement the account in our last issue (p. 46) of the 21st annual meeting, held in Minneapolis, June 24 to 26, with the following additional notes:

A paper by Professor E. V. Huntington, of Harvard University on "The Units of Force" was partly instrumental in causing the appointment of a Committee on the Teaching of Mechanics to Engineering Students. In another paper Mr. D. M. Wright, of the Henry & Wright Mfg. Co., suggested the appointment of a committee to study and report upon the standardization of technical terms. This suggestion was carried out.

The presidential address of Professor Wm. T. Magruder, of the Ohio State University, was devoted to the qualifications required in a good instructor. He pictured an ideal instructor as one who knows his subject but is also in mental reach of his students; who has the highest reputation for honesty, right living, patience and sound character; who is in practical touch with the subjects he has to teach and who has unbounded enthusiasm for the work of both teacher and engineer.

The general subject of academic efficiency was discussed by Professor H. S. Person, Director of the Amos Tuck School of Tuft's College. President A. C. Humphreys, of the Stevens Institute of Technology and Professor G. F. Swain, of Harvard, championed the four-year as against the course requiring five years or longer, while the opposition was led by Professor F. H. Constant, of the University of Minnesota.

The results of the operation of the systematic grading system in use at the University of Missouri was described by Professor A. L. Hyde. Professor F. P. McKibben, of Lehigh University, called attention to the advantages of summer work for engineering students and explained how his students arrange for such work.

A very interesting session was devoted to engineering college shop practice and engineering drawing. Professor J. V. Martenis and Mr. W. H. Richards described how shop work is made attractive and stimulating to the students by making exercises lead to something definite. An extensive exhibit was used to illustrate the working out of the plan. Professor T. E. French, of the Ohio State University, a most successful teacher of engineering drawing, showed how this subject can be taught effectively.

Among other papers, one by Professors C. E. Sherman and R. K. Schlafly, of the Ohio State University, described a novel practice of sending civil-engineering students into commercial work during the summer under the direction of instructors if the students could not obtain regular summer employment. Professor H. Wade Hibbard, of the University of Missouri, presented directions for thesis work and gave a long list of subjects suitable for investigation.

The following members were elected to serve for one or more years in the positions indicated: President, G. C. Anthony, Tuft's College, Mass.; Vice-Presidents, H. S. Jacoby, Ithaca, N. Y., and D. C. Humphreys, Lexington, Va.; Secretary, H. H. Norris, Ithaca, N. Y.; Treasurer, W. O. Wiley, New York, N. Y.; Councillors, H. W. Tyler, Boston, Mass.; J. F. Hayford, Evanston, Ill.; A. S. Langsdorf, St. Louis, Mo.; S. M. Woodward, Iowa City, Iowa; M. S. Ketchum, Boulder, Colo.; F. P. Spalding, Columbia, Mo., and P. F. Walker, Lawrence, Kan.